Kennelly Notebook #6

This notebook covers the period January-December 1892. It contains transcriptions by Arthur E. Kennelly of material from the rough record books used by experimenters in the Galvanometer Room. There are notes, drawings, tables, and calculations regarding a variety of electrical experiments, including tests of meters, cable and cable insulation, batteries, and dynamos. In addition, there are extensive notes and design drawings relating to motors for phonographs, rock drills, and fans, including an alternating current fan motor design. Also included are notes regarding the alternating current electric power system in Newark, N.J., the electromagnetic properties of iron and nickel, physiological experiments on the effect of electric current on muscle action and blood flow, along with theoretical notes concerning physics, electricity, and mathematics. Among the experimenters whose work appears in this book are Alfred J. Thompson and Arthur Hoopes. At the end of the book is a subject index (filmed at the beginning of the book). The front cover is marked "VI" and" 1892." The book contains 161 numbered pages. Some pages were removed before the book was paginated. Numerous graphs, photographs, blueprints, and other items have been pasted into the book.

A.

Armature frame – hexagonal composite for ½ HP fields 24
Ammeter – alternating current, calibration of for Auburn 36
Alternating current – primary pressures taken at Newark (Mr Thomas) 94
" " – Epitome of Measurements taken 99-105

B.

Brass casting – made from wooden pattern 19

C.

Copper Bell Meter, Tests of 3
Copper Bell Meter, Test of 6
Copper Bell Meter, Test of 7
Copper Bell Meter, Special Test of, 11
Copper Bell Meter, Test of, 14
Cost of Conductor, to carry 1000 HP. 25 miles with 7000 volts (or 1) 30% loss, Calculations on, 8
Calculations of Drop in pressure, over Trenton 1886 system 17
Capacity test, of various compounds 9
Capacity static — of certain samples of cable (test taken as below) 23
Capacity — and resistance of telegraph lines from Jersey City to Albany 39
Current strengths in C.N.W.R. lines, measurements made by Mr Tate 41
Conductivity — Matthessens Standard of 71

D.

Digest of report from Mr C.D. Smith to Engineer in Chief S.E.E.Co 10
Dynamo, Particulars of a 300 K.W.T. Multipolar 18
Dynamo - 100 K.W.T. at 10,000 volts, Electromagnetic design for Co 22
Dynamo Test 200 K.W.T. at 26th Street Station, particulars of 39
Dynamometer - data for new double - for transformer tests 23
Dynamometer - Differential type - measurement of constant 46
Dynamometer - differential type - measurement of constant 56
Diaphragm displacements - measurement of 81
Diagram - analysis of taken from E.D.E.Co Engine at Elm St. by Mr Phelps 98.

E.

Edison Reversed Cells, Local action test of . 5
Estimate for Power Transmission 16
Edison Lalande and Lalande Zinc line record of 5
" " for B.N.W.C. Lines in Toronto 35
" " Test of new plate holder 45
" " local action test 54
" " test of 65
" " Cautery or 1 cell resistance of 65
" " test of new sample of Zinc 85
Ether luminiferous - density of - Mr Thomson method 36
Electric freight railroad from Anaconda to Butte Mt 11
Electrocution - Mr Ivaine particulars observed at 32
Electric Light work estimates on 41
Electromagnet large, experiment with - fitted with conical pole. 98

F.

Foucault currents in Copper Arago disk between poles of magnet 26

G.

Unit resistance – compared with 0·01 Substandard 103

H.

Hysteresis – test of in nickel wire ring 20
" " " 2nd " " " 29
" – measurement of in nickel 39. 40. 42.

Iron pings received from ~~Schenectady~~ – particulars of 57
" " Cost of 63–64.
" " permeability of 60
" " malleable samples received from ~~Schenectady~~ Hopton 86, 87, 88, 91, 92
" " – Experiments on annealing 95
Insulation – Glucose wires in cables experiment on 68
" One measurement 89
" " of in iron 94
" " " " Overhead wires 100
" " 101

K

L

Lamps – 16 C.P. posis of at various current strengths 32
Lead sheathing of telephone cables
" corrosion experiments on, 49, 50, 55, 57, 62 (Ex. W.E.), 66

M.

Magnolium experimental research in

38.

M.

Motor, Outline of Magnetic Circuit for Torque Regulating 13
Motor, Weston-Wheeler arc light circuit with Copper Ball 15
Motor - speed controlled - test of small model 14
" - 6 HP test of on first completion 30
" magnetic test of 120 Volts 30
" Edison slow speed - synopsis of data for 31
" Corresponding data for 31 A
" Excelsior fan test of 33
" 6 HP hexagon armature, 120 & 500 Volt test of before delivery } - 37
" Ballony fan design of 43
" " " amended design for a 51
" 500 Volt efficiency test 56
" 120 Volt ½ HP Edison 58
" ½ HP with bridges connecting poles 59
" Diehl 110 Volt fan - test of 66
" Test of Edison Model 66

Motor Copper ball on page 3.6.7.8.10. (11 with metal surface) 12. 14. 25.
" Edison Oval recording test of 44
" Alternating current for patent case 85
" " test of 89
" " " designed for Edison Patent case 76
" " " " " " winding for 165

These are also entered under C of Index

Motor - 500 Volt test of 81 - 83
" - Phonograph type of - designed for battery 80
" - ½ HP test of 77
" ½ HP test of after increasing bearings 74
" ½ HP composite frame 70
" 1/6 HP 69
" 1/12 Crocker Wheeler. Fan 67

N

N.P.R.R. officers - facts elicited by at the Laboratory 8

O

P. Power transmission, estimate of 1000 HP for 16 miles 19
" " " " 16
" " " " 1000 HP for 25 miles
@ a pressure of 7000 Volts. Cost of conductor for 8
" necessary to operate Archive organ in
Mr Edison's house. 79
Phonoplex receiver – resistance and inductance of 79
Physiological experiments 90–97

Q

R. Rock-drill – trial of operated by motor 5
" " test of Cam Electric 12
Relay – Arnall electromagnetic – tractive force of 34
" Western Union – measurements with 73
" Test of method after changing armatures 78
Resistance – standard – measurement of 101

S.

Specific Inductive Capacity Measurements 1.
Specific Inductive Capacity, Collection of results 2.
Skua of Small Model, Test of 4.
Storage cell - Ernst. test of 93
Siemens cable carrying capacity of 106, 107

T.

Transformer - 5 K.W.T. 100 ~ test of 13
" now built, synopsis of data relating to 27
" 2 K.W.T. winding of for 10,000 Volts 28.
" tests with differential dynamometer 47, 48. 52, 53.
" losses measurement of contd 53
" Edison patent, Efficacy of 62 & 75
Trenton 1886 system - calculation of drop over 17
Telegraph lines to Philadelphia - specifications for 79
" Cable - received from Schenectady. test of. 82
Temperature coefficient of copper, - Matthiessen & Hurdock Determination of 104

U.

V.

Voltmeter Weston - test of after repair 58
" Static - trial of 600 Volt scale 70
" " - 1000 Volt. test of 79
" " - Design to operate on 120 Volts 102
" test - Comparison 84

W

Winding space — maximum hexagonal form armature 19
" Calculation for " 97
Wattmeter Kohlbrausch Dynamometer 28
World's Fair at Chicago — facts in connection with lighting of " 125

X.

A 5931-6

№ VI.

Record Book

of

Observations, Calculations, and Data

compiled in the Galvanometer Building

Edison Laboratory, Orange N.J.

commenced 1st January 1892.
completed 2nd December 1892.

Specific Inductive Capacity Measurements.

Jan: 2nd Air condenser standard zinc plates. 922·6 sq. cms 0·098 apart.
600 ÷ 2 volts = 67·2 divs.

Condenser with iron plates, preparation of stearic acid containing 2½ % of PbO_2, resulting in a small admixture of lead stearate
930·3 sq. cms 0·098 50 volts 84·5 divs. 6 divs: leakage.

S. I. Capy $\frac{6 \times 84{\cdot}5}{67{\cdot}2}$ = 7·5.

It was found on separating the plates that much of the surfaces were left unoccupied by the stearate, which had cooled too quickly. The real capacity would therefore probably have been greater than the above observation showed.

Japan wax. 210 divs: 300 volts ½ div. leakage

Capacity $\frac{210}{68}$ = 3·09.

Jan: 4th Stearic acid fairly pure

Leakage 7 divs 300 volts.

Air condenser 922·6 × 0·098 300 volts 68·5 divs.

Iron " 930·3 × 0·098 50 volts 44·75

Sp. I. K = 3·92

N. B. The stearic acid tested some days previously (17th Dec). had been boiled in a Jena kettle and was probably impure on that account. It may have contained an appreciable quantity of lead stearate.

Mixture of crude ozokerite with Kerosene oil.

Iron condenser (air) before pouring 930·3 × 0·098, 300 volts 109 divs
after " " 0·173 200 " 132 "

Sp. I. K. $\frac{132}{109} \times \frac{E}{2} \times \frac{173}{98}$ = 5·34

This is a much higher value than that obtained with either Kerosene or crude ozokerite.

Constant ½ Pl. Black cell 300,000 ω 47 divs. = $\frac{1{\cdot}734 \times 10^{-1}}{{\cdot}3 \times 10^{6}}$ = $5{\cdot}8 \times 10^{-7}$ amp.

1 div: thus represents $1{\cdot}234 \times 10^{-8}$ amp

res: abs: = $E/(1{\cdot}234 \times 10^{-8} \times \frac{E}{d})$ and resistivity = $1/(1{\cdot}234 \times 10^{-8}) \times \frac{E}{d} \times \frac{930}{h}$ = $1{\cdot}148 \times$
= $8{\cdot}104 \times 10^{7} \times 930 \frac{E}{dh}$ = $7{\cdot}537 \times 10^{10} \frac{E}{dh}$

Aniline oil. — Useless. Resistance 930 × 0·098 about 13000

Camphor oil — Similarly useless.

Lead Stearate — melted, poured overnight, and cool — useless.

Jan: 7th Turpentine — 1000/300,000 — 25 divs.

Sweet almond oil 10 in 300,000 20 divs.

Oil of lignite 1000/300,000 8 divs.

Oil of fennel 10 / 300,000 ½ div.

Turpentine oil monohydrate bad.

Benzole boiled. This measurement was not very accurate because the surface between plates was not quite filled, about 12·5 sq cms missing.

Air condenser zinc 101·9 divs 250,000 / 300,000.

Benzole boiled 209·3 — 150,000 / 300,000. Ratio 111·3 117·2

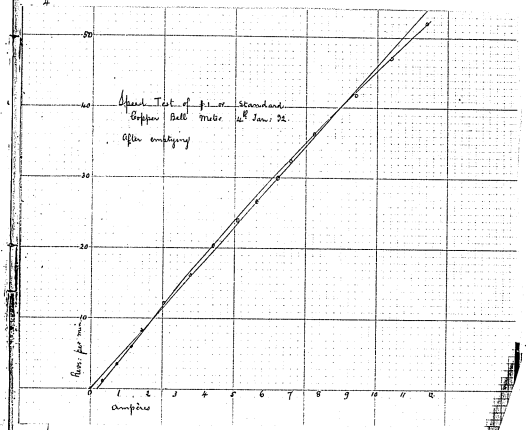
leakage " 2 divs. 250,000 / 300,000

Collection of results obtained in Spec: Ind: Capy: Measurements

(continued from V p. 116)

No. of Obs.	Date. Years	Substance	Formula	Testing Rms	Leakage divs	Constant	S.I.R.	Res.	ρ
1	2nd Aug. 1	Stearic acid + lead stearate		300	36	8.108×10^{7} E/H	> 7·5	6.84×10^{8}	6.9×10^{14}
2	" 1	Tallow oil		300	0·5	-	3·1	4.9×10^{10}	4.5×10^{23}
3	4th 1	Stearic acid		300	7	-	3·9	3.47×10^{9}	3.23×10^{22}
4	" 1	Oxide of zinc mixed with turpentine		300	0·5	.	5·3	4.9×10^{11}	4.5×10^{23}
5	" 1	Aniline oil		-	-		—	1300	—
6	5th 1	Camphor oil		-	-		—	bad	
7	5th 1	Lead stearate		-	-		—	-	
8	7th 1	Turpentine					—	-	
9	" 1	Sweet almond oil					—	-	
10	" 1	Oil of lignite					—	-	
11	" 1	Oil of fennel					—	-	
12	" 1	Turpentine oil saturated with Barnsdale's					—	-	
13	" 1	Spermaceti				8.77×10^{7} E/H	3·22		
14	8th 9	Spermaceti					6·86	good	
15	" "	Asphalt					—		
16	" "	Rosin					2·29	very big	
17	" "	Oleic acid					—	bad	
18	12th "	Benzene					2·072	1.62×10^{16}	1.44×10^{24}
19	" "	Benzene + Rosin				9.03×10^{7} E/H	—	1.28×10^{21}	
20	" "	Rosin in benzene					3·11	3.39×10^{16}	3.22×10^{24}
21	" "	Lignite part of the					—	1.03×10^{16}	9.77×10^{17}
22	" "	Balsam Copaiva					—	2.22×10^{16}	2.11×10^{24}
23	" "	Commercial oleic					-	—	—
24	" "	Benzole					-	1.39×10^{13}	1.32×10^{18}
25	" "	Oil of sweet bay (Laurel)					2·65	7.06×10^{16}	1.67×10^{24}

No. of Obs.
1
2
3
4



Tests of Copper Bell Meter 4th January 92.

No. 1. or standard.

The instrument was emptied of mercury, the bell removed, and then set up afresh. Paraffin oil (sp.) was poured on the surface of the mercury. The torque was then measured as follows:—

Observer A.H.

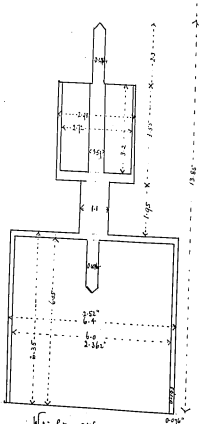
No. of Obs.	Weight of Carriage	Weight lifted	Total Wt	Rad. of Shaft	Torque cm.-gms.	Mean Ohmic	Mean Amp.	Torque per amp.	Mean result
1	0.25	10	10.25	0.2625	2.691	0.3935	2.03	1.326	
2		20	20.25		5.316	0.7425	3.831	1.388	
3		30	30.25		7.941	1.1125	5.741	1.383	
4		40	40.25		10.57	1.5025	7.753	1.363	
		50	50.25		13.19	1.835	9.467	1.393	1.371 ± 0.009
		1.50	1.75	0.	0.463	0	0		

The speed was then measured as follows:—

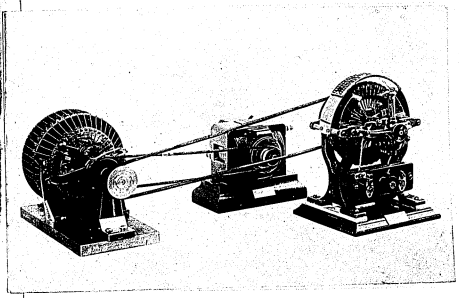
Observer A.H.

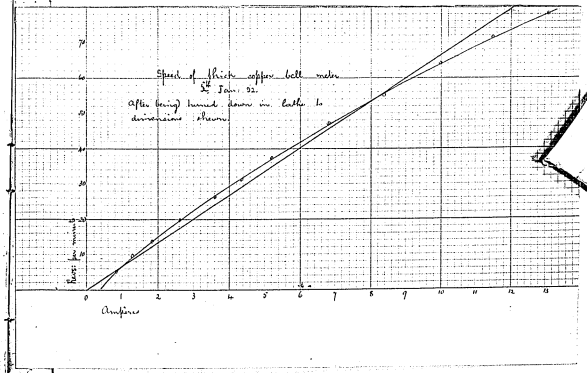
Lamps	Ohmic	Amp.	Revs.	Time, secs.	Revs. per min.	Revs. per min per amp	Revs. per min per amp. after correction	
1	0.074	0.382	2	117.5	1.02	2.67	2.67	
2	0.166	0.857	4	66.4	3.61	4.21	4.21	
3	0.257	1.326	6	59.2	6.08	4.59	4.59	
4	0.346	1.785	9	65	8.31	4.65	4.65	
6	0.500	2.581	12	59.2	12.16	4.71	4.71	
8	0.673	3.473	16	58.8	16.3	4.69	4.69	
10	0.830	4.283	21	62	20.3	4.74	4.74	
12	0.985	5.083	24	60.2	23.9	4.70	4.70	
14	1.107	5.712	27	60.6	26.7	4.68	4.68	
16	1.258	6.491	30	60	30.0	4.62	4.62	
18	1.346	6.945	32	59.6	32.2	4.64	4.64	
20	1.520	7.843	34	56.4	36.2	4.62	4.62	
24	1.79	9.24	42	60.2	41.9	4.54	4.54	
28	2.04	10.53	47	60	47.	4.47	4.47	
32	2.28	11.76	52	60	52.	4.42	4.42	

Full-size section of Thirlway belt.



Weight 37½ grs.





Test of a small model speed-controlled motor No. 1 Jan. 92.

Two Pacinotti's toothed gramme ring armatures were taken from two small Edison ½ H.P. motors. One of these was fixed in the vertical plane, while the other was mounted on a shaft immediately by its side and allowed to turn closely adjacent to it. On a sleeve over this armature shaft, bore two pairs of brushes, one pair running on a commutator for the field, and the other at right angles running on the commutator. The sleeve and brushes were driven by a small Perret motor, and with 2 amp. in the field circuit, running about 500 rev. per minute the emf generated by the armature (stationary) was about 2 volts. On closing the armature circuit the armature began to revolve until its speed was nearly equal to that of the brushes. On connecting the armature circuit through a few lamps in the main, the speed of the armature fell almost zero to full speed by altering the speed of the auxiliary Perret motor driving the brushes. The torque exerted by the motor taken as a whole machine was small, owing to the small size and the inconvenient method of assembling it, with armature and field side by side. Also when the armature was allowed to stop, a new pull was needed on offset to start it owing to the Pacinotti teeth all facing each other. Machine preserved.

Tests of Standard Copper Bell. motor 4th Jan. 92.

The bell was removed, and the magnets were struck with a mallet a number of times with as much severity as they could fairly stand mechanically. The bell was then replaced and a series of torque measurements made.

No. of Obs.	Weight of Carriage	Weight lifted	Total weight	Rad. of shaft	Torque cm-gram.	Mean Obsvd.	Mean amp.	Torque per amp.	Mean result
1	0·25	10 g.	10·25	0·2625	2·691	0·392	2·023	1·330	
2		20	20·25		5·316	0·7465	3·852	1·380	
3		30.	30·25		7·941	1·140	5·882	1·350	
4		40	40·25		10·566	1·4675	7·572	1·395	
5		50	50·25		13·191	1·8475	9·533	1·384	1·388±·001
6		5	5·25		1·377	0	0	0	

Test was next made with the thick copper bell at standard torque (1·388)

No. of Obs.	Lamps	Obsvd.	Amp.	Rev.	Time	Rev. per min.	R.p.m. per amp.	r	
1	2	0·161	0·831	6	68·2	5·28	6·35		
2	3	0·254	1·306	10	61·2	9·80	7·5		
3	4	0·350	1·801	14	61·0	13·77	7·65		
4	6	0·507	2·636	21	63·8	19·75	7·49		
5	8	0·692	3·571	27	61·8	26·23	7·35		
6	10	0·842	4·345	32	60·4	31·79	7·32		
7	12	1·022	5·274	39	62·8	37·26	7·06		
8	16	1·32	6·811	46	59·4	46·5	6·83		
9	20	1·62	8·359	55	60	55	6·58		
10	24	1·94	10·01	64	-	64	6·40		
11	28	2·23	11·51	71·5	-	71·5	6·21		
12	32	2·54	13·11	78·5	-	78·5	5·99		

Local action Test of Edison-Lalande cells. Jan. 6th 22.

Three Edison-Lalande cells of different sizes in porcelain jars were set up at the same time as three Lalande cells from Frances in glass jars. The zinc plates in the former are held in position apart from the pots solely by the top clamps. In the French cells they are held by a rubber band encircling zincs and cups against tiny hard rubber projections. The same solution of NaHO was used for each. The same oil was used on the surface of each.

No. of cell	Weight of Zinc	Observed total weight	Volume of solution	Height inches	Diameter Depth inches	External diameter inches	Internal Top inches	Diameter Bottom inches	Size of Zinc plate Depth	Size of Zinc plate Breadth
Edison cells										
1	129		580+50cc	5·5"	5·4"	3·75"	3·4"	3·1"	4"	× 1·5"
2	277 / 270		2930+70cc	8·5"	8·0"	6·75"	6·25"	5·75"	5·1"	× 2·8"
3	347 / 347 / 347	933	2980+80	11·25"	10·75"	5·75"	5·25"	5·0"	7·25"	× 2·75"
Lalande cells										
4	197	197	720+50	6·4"	6·0"	4·1"	3·75"	3·55"	3·7"	× 2·15"
5	367 / 367	734	2680+70	10·5"	10·1"	5·6"	5·0"	4·75"	4·8"	× 4·3"
6	373 / 373 / 374·5	1120	5050+100	12·8"	12·3"	6·5"	5·9"	5·9"	4·9"	× 4·3"

The cells were set up and left aside on open circuit, for the determination of zinc losses by local action.

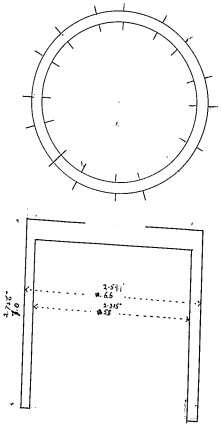
Trial of a Rock Drills operated by a motor

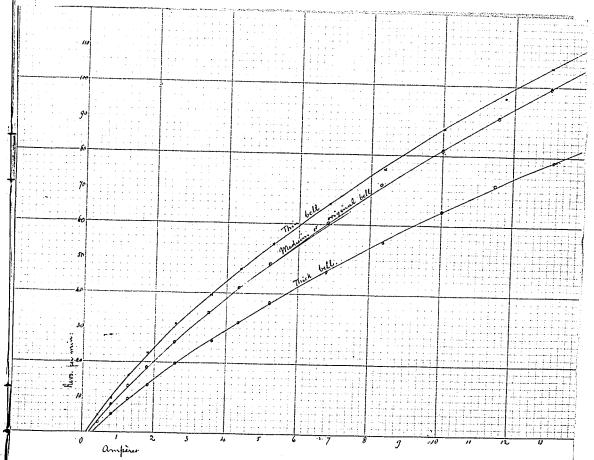
The drill is raised and lowered through a 3" stroke against a compressed spring, by a Sprague series motor geared 4:1, worked on a 500 volt circuit. When making 124 strokes per min: = 496 r.p.m. of armature, the current was 7·5 amps at 600 volt p.d. = 4·5 KWTs. The force of the spring was 250 lbs: (including weight of rod) at full compression, say 220 lbs: in the spring. The work done at each stroke is therefore 110 × 0·25 + 30 × 0·25 = 35 ft. lbs: per rev and 125 strokes = 4375 ft lbs: per min.

Twice Record of the above Edison Lalande + Lalande Zincs

No. of Cell	Date Jan. 15th	Jan. 20th 10 days	Mar. 21st 65 days
1	120	120	101
2	277 / 277 } 554	277 / 276 } 553·5	277 / 279 } 556
3	310 / 310 / 310 } 930	310·5 / 309 / 309 } 928	300 / 301 / 301 } 902
Total	1620	1616·5	1560
Loss	100 0	99·66 0·34	96·3 3·7
4	197 197	120	bottom off
5	367 / 367 } 734	367·5 / 365 } 733	bottom off
6	373 / 374·5 / 374·5 } 1120	371·5 / 370 / 370·5 } 1117·5	360 / 353 / 353 } 1066
	2366	1990·5	1066
Loss		95·36 2·36	

The total weight of zinc for each cell is in all cases taken from summation weights, and not obtained by addition.

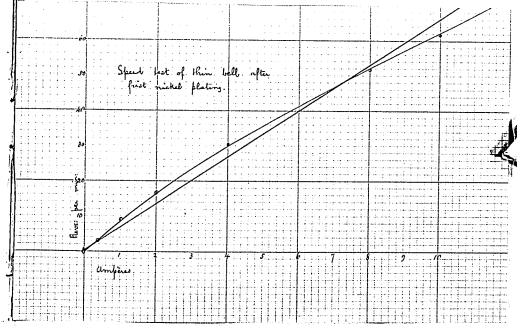

7/16"
10
2.99"
.66
2.15"
.53


This belt
Modified or present belt
This belt
Amperes
0
1
2
3
4
5
6
7
8
9
10
11
12
13

Tests of Copper Bell Meter 6th Jan: 91.

Three copper bells nos (1) (2) and (4) were tested in the electromagnetic field so as to obtain as nearly as possible uniform conditions.

No of No	Bell	Torque per amp	Amps	Watts	Amps	Revs. per min	R.p.m. per amp
1	Thick # 4	1.395	1			0	
2			2	0.161	0.831	5.28	6.35
3			3	0.254	1.306	9.80	7.50
4			4	0.350	1.801	13.77	7.65
5			6	0.507	2.626	19.75	7.49
6			8	0.692	3.571	26.23	7.35
7			10	0.842	4.345	31.79	7.32
8			12	1.022	5.274	37.26	7.06
9			16	1.32	6.811	46.5	6.83
10			20	1.62	8.359	55.	6.58
11			24	1.94	10.01	64.	6.40
12			28	2.33	11.51	71.5	6.21
13			32	2.54	13.11	78.5	5.99
1	Thin # 2	1.395	1	0.089	0.459	5.02	10.94
2			2	0.161	0.831	9.90	11.91
3			3	0.252	1.3	16.7	12.82
4			4	0.350	1.806	22.8	12.62
5			6	0.507	2.616	31.1	11.89
6			8	0.689	3.555	39.6	11.14
7			10	0.854	4.407	47.	10.66
8			12	1.030	5.315	54.3	10.22
9			16	1.325	6.85	66.	9.63
10			20	1.63	8.41	76.	9.04
11			24	1.95	10.06	87.5	8.70
12			28	2.28	11.76	96.5	8.21
13			32	2.53	13.05	105.5	8.09
1	Medium # 2	1.395	1	0.094	0.433	2.91	6.49
2			2	0.160	0.826	8.01	9.70
3			3	0.248	1.280	13.42	10.48
4			4	0.341	1.760	18.43	10.47
5			6	0.500	2.580	26.04	10.09
6			8	0.679	3.504	34.43	9.83
7			10	0.841	4.340	41.3	9.52
8			12	1.013	5.227	48.5	9.28
9			16	1.31	6.760	60.3	8.92
10			20	1.61	8.308	71.5	8.61
11			24	1.94	10.01	81.5	8.14
12			28	2.24	11.56	91.	7.87
13			32	2.53	13.	99.5	7.65


Speed test of Rim bell, after first nickel plating.
Time in sec.
Amperes
1
2
3
4
5
6
7
8
9
10
10
20
30
40
50

Tests of copper bell motor 7th Jany. 92.

A trial was made of supplying the current into the upper surface of the mercury instead of at the upper electrode cup. For this purpose the guard plate was removed, and a nickel-plated electrode floated on the mercury surface. It was found that when supplied in this way the bell would rotate with the current from one lamp although it sometimes hesitated and would not start. The thin copper bell was used in its varnished state, so that the current had to pass entirely through the mercury between the bell and the outer walls. The speed of rotation for a given current was found to be reduced. The following torque measurements were made:—

10½" Stk.

No. of Obs.	Total weight lifted	Torque oz. in.	Ascending amp.	Descending amp.	Mean amp.	Torque per amp.	Mean
1	1.0	0.238	–	–	–	–	
2	5.25	1.249	2.369	1.781	2.075	0.602	
3	10.25	2.439	5.17	3.793	4.481	0.544	
4	15.25	3.629	7.946	5.83	6.888	0.527	
5	20.25	4.819	10.34	8.642	9.491	0.508	0.545

The torque therefore diminishes with the current when the copper bell acts only as a float.

To cause the current to enter the copper bell, an annular portion of the upper surface was cleaned and nickel plated. An annular nickel electrode was similarly fixed into an upper wooden cover. The following measurements of torque were now made. Tem. 11°·40'

No. of Obs.	Weight of Carriage	Weight added	Total weight lifted	Torque oz. in.	Descending current	Ascending current	Mean amp.	Torque per amp.		
1	0.25	10	10.25	2.439	2.374	2.348	2.361	1.033		
2		20	20.25	4.819	4.335	4.826	4.581	1.052		
3		30	30.25	7.198	7.044	7.482	7.263	0.991		
4		40	40.25	9.580	9.70	10.12	9.91	0.967		
5		50	50.25	11.96	12.13	12.77	12.45	0.961		
6		0.25	0.5	0.119	0	0	0	0		

The following speed test was then taken.

No. of Obs.	Lamps	Clock	Amp.	Time sec.	Revs.	Revs. per min.	Rev. per min. per amp.		
1	1	0.074	0.382	72.4	4	3.315	8.68		
2		0.194	1	66.6	10	9.0	9.0		
3		0.388	2	60	16.6	16.6	8.3		
4		0.776	4	"	30.2	30.2	7.55		
5		1.552	8	"	51.3	51.3	6.4		
6		1.940	10	"	61.9	61.9	6.19		

On the Cost of a Conductor required to carry 1000 H.P. a distance of 25 miles with 7000 volts p.d. (mean) and 30% loss.

Earth return circuit. Motor efficiency 0.93. No leakage.

1000 H.P. = 746,000 watts and at motor terminals = 802 KW.Ts

30% of 7000 = 2100, leaving 4900 volts and 163·7 amps on line

2100 ÷ 163·7 = 12·83 ω for 25 miles = 0·5132 ω per mile

= 113,000 cir mils = 1810 lbs per mile or $1400 per mile @ $0·22 per lb.

Facts elicited at the meeting of N. P. R. R. Officers & Engrs Laboratory 8th Jany. 93. (? 92 NYS)

An empty sleeping car weighs 95,000 lbs.

Large standard locomotives carry 160 lbs of steam with cylinders 22" × 24" – 4' drivers, cost $20,000, burn 6 lbs per H.P. per hr.
This is equivalent to a pressure of 60,800 lbs on crosshead or 30,400 lbs at axle.

Grades on N.P.R.R. do not exceed 1% except in the mountain section.

Distance between track centres on double track roads is 13'0".

A loaded passenger car may weigh 95,000 lbs.

No fences line the NPRR track.

A casualty occurring on a track by reason of a person crossing it may cost in enforced legal penalty or damages. This is even when the track is fenced in.

Experiments with copper bell meters. 9th Jany 92.

All three bells were coated with nickel plate over their entire external surfaces, the interior surface being varnished.

The thin bell then made 76 r.p.m. on 10 amps with 10½" in ring. Turns in field instead of 62 as found yesterday. The starting friction was however much increased, and this was traced to a magnetic pull on the nickel plating. Thus the starting friction with the thin copper bell was found to be 1·0 gms at shaft radius with no magnetising current in the separately excited field. The normal field excitation raised the starting friction to 3·5 gms, and a strong field to 5.0 gms. total weight.

Capacity Tests of various compounds.

Asphalt: Poured in hot – plain mexican asphalt – Thickness of stratum could not be subsequently determined. a large number of bubbles being weighed with the mass 117.25 div 250,000/300,000
Air condenser 100 250,000/300,000.

Spermaceti :– 930.25 × 0.098 – 50,000/300,000 – 138.5
– × 0.098 air 250,000/300,000 – 101 div.
Leakage 25000/300,000 – 1 div. nearly.
Capacity – 6.86

Oleic acid :– 930.25 × 0.098 – 65 div: leakage 50/300,000 –

Rosin :– 930.25 × 0.240 – 250,000/300,000 – 92.75 div
× 0.098 air – – – – 102.
Leakage 92.75 / 90.75 after 60 secs. = 3.30×10^{12} ω = 3.3×10^{11}
Capacity $\frac{0.240}{0.098} \times \frac{92.75}{102}$ = 2.23. $\rho = 1.25 \times 10^{14}$

Rosin repeated :– 930.25 × 0.21 250,000/300,000 – 117 div.
922 × 0.098 Zinc air – – – 105
Leakage 117/115 after 60 secs.
Capacity $\frac{117}{105} \times \frac{0.21}{0.098}$ = 2.34

Mean 2.29

12th Jany. Benzine :– $\frac{250,000}{300,000}$ 27 div. leakage Res. 1.62×10^{14} $\rho = 1.44 \times 10^{22}$
930.25 × 0.098 250/300,000 – 223 div
× 0.0798 – – 107.6
S.p. G. K. 2.0722

5th Jany. Burgundy Pitch :– 930.25 × 0.7 The leaper could not be estimated perhaps 0.25
Pitch: 250,000/300,000 – 131 div $R = 1.28 \times 10^{24}$.
after 1 min insulation. 126 – $\rho =$

Rosin + Kerosene oil + some benzine. 209 div :– 930 × 0.098 $R = 3.29 \times 10^{12}$
Air condenser 105 $\frac{250,000}{300,000}$ $\rho = 3.22 \times 10^{13}$
S.p. G. K = 3.11

Liquid Kerosene and such Rosin as it had dissolved. $R = 1.03 \times 10^{16}$
Leakage too great for capacity obs. $\rho = 9.71 \times 10^{19}$

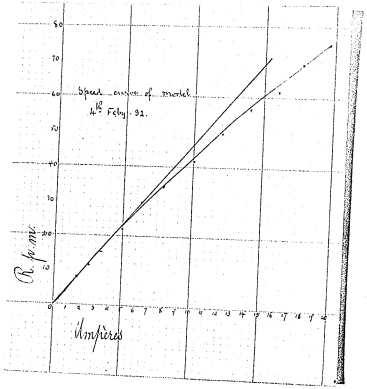
Balsam Capavia $R = 2.22 \times 10^{16}$ $\rho = 2.11 \times 10^{20}$
Capacity could not be observed.

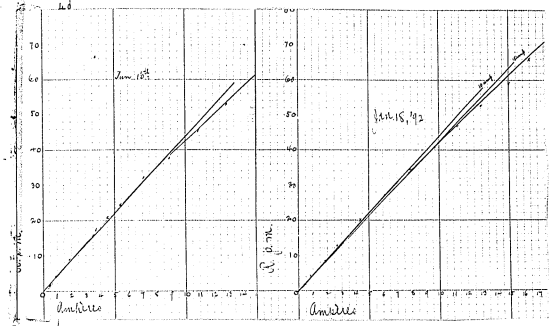
Kerosene + rosin (liquid part – solution of rosin in Kerosene oil) $R = 8.93 \times 10^{15}$
$\rho = 8.38 \times 10^{17}$
Capacity not observable

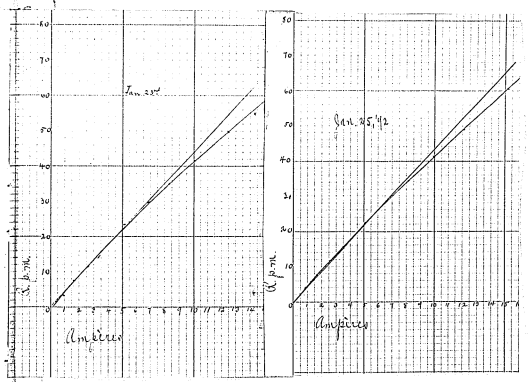
Commercial alcohol – very infair insulation

Benzole $R = 1.39 \times 10^{13}$ ρ 1.32×10^{18}
Capacity not observable

Oil of wood tar Air condenser 106 $\frac{250,000}{300,000}$ 930 × 0.097
Tar – with tar. 102.3 930 × 0.281
S.G.K. = 2.65 $R = \frac{102.3}{97.7} \times 0.060$ ω $R = 5.06 \times 10^{20}$ $\rho = 1.67 \times 10^{19}$


Speed curve of model
4th Feby. 92.
R.p.m.
Amperes


Jan. 18th
Jan. 18, 92
R.p.m.
Amperes


Jan. 25th
Jan. 25, 92
R.p.m.
Amperes

Digest of a Report from Mr C. H. Hewitt to The Engineer in Chief Edison General Co.

Troubles were found at the Power House of the Erie R.R. Co from the pitting and corrosion of their buried iron pipes that supply water. The road was originally operated by horses. When converted to an electric road, the rails were bonded with copper wire, no track wire was used, but a piece of old rail connected to back was driven into the ground every 400 or 600 feet. It was found that the iron water pipe system was carrying a share of the return current, so at ~~some distance~~ five, ~~but probably~~ 2 years ago the ground circuit was connected to the water pipes in the station, between the feed pump and the heater. Since that time the water pipes have given continuous trouble. Specimens forwarded to the laboratory show pitting and corrosion, such as might be caused by Electrolysis.

Measurements were made as detailed in the report going to show that of the average current supplied to the line – 220 amperes, about 20 passed into the water pipes by the pump connection in the station, and 130 by the overhead copper wire leading to the rails. The positive bus was in connection with the ground. While the pressure between the overhead holley line and track was 493 volts, 480 were found between holley and pipe.

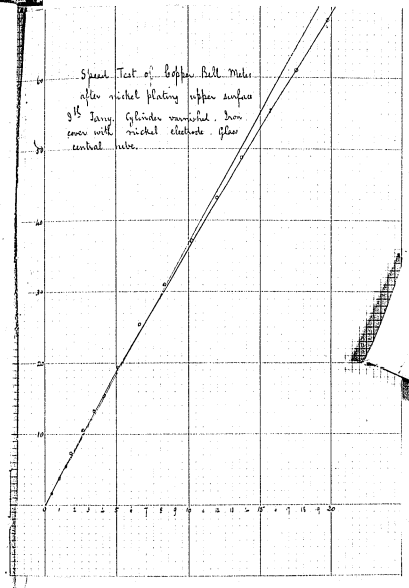
190 amperes converting Fe into Fe_2O_3 or ferric salts would consume 1390 gms daily
" " Fe_3O_4 " ferrous " " 2090 "

Tests of Copper Bell Meter after nickel plating top only.

In view of the bad effects produced by nickelplating the cylinder as recorded on the preceding page, the bell was varnished on the sides but left nickelplated on the top surface and lower rim. The following torque measurements were then made in the P.M. field, with new lid and nickel electrode.

No of Carriage	Load	Total Wt	Rad of shaft	Torque cms gm.	Dec. current	Acc. current	Mean current	Torque per amp.	Mean
0.25	0.20	0.45	0.261	0.118					
	10	10.25		2.68	2.343	2.358	2.350	1.140	
	20	20.25		5.286	4.469	4.567	4.518	1.170	
	30	30.25		7.896	6.512	6.914	6.713	1.176	1.160
	40	40.25		10.505	8.986	9.158	9.072	1.158	
	50	50.25		13.12	11.15	11.51	11.33	1.158	

From this series it would appear that with the top of the bell plated, the torque is nearly proportional to the current up to 12 amp.


Speed Test of Copper Bell Metal after nickel plating upper surface 9½ Inch Cylinder varnished. Iron cover with nickel electrode. Glass central tube.
10
20
30
40
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

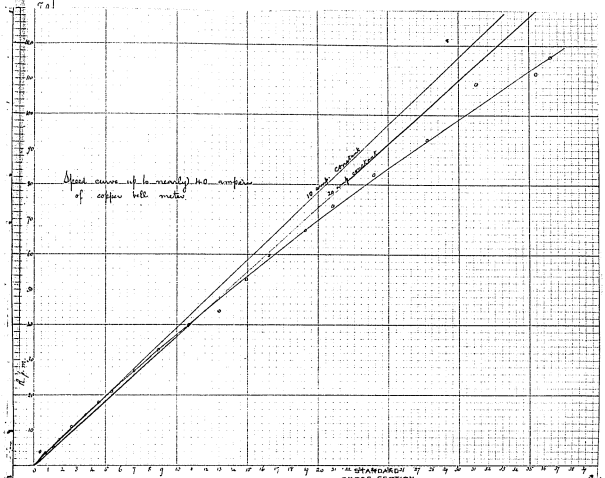
Speed Test of Copper Bell Meter with nickel plated upper surface 9th Jany.

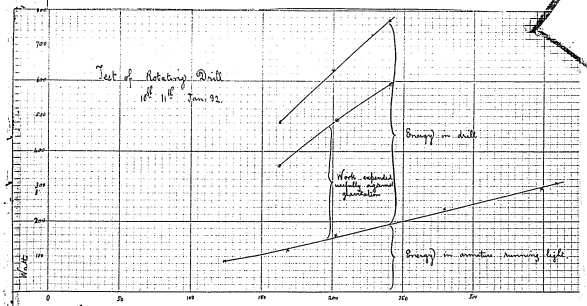
No. of Obs.	Lamps.	Obsch.	Amp.	Revs.	Time	R. p. m.	Revs p. amp.
1	1	0.893	0.480	2.0	66.8	1.796	3.74
2	2	1.193	0.944	4.0	62.4	3.846	4.073
3	3	0.260	1.342	6.0	65.8	5.471	4.077
4	4	0.341	1.76	8.0	66.6	7.208	4.096
5	6	0.509	2.627	11.0	63.2	10.444	3.975
6	8	0.669	3.350	14.0	63.6	13.21	3.943
7	10	0.813	4.196	16.0	58.6	16.38	3.904
8	12	0.981	5.063	19.4	60	19.4	3.832
9	16	1.283	6.62	25.3	-	25.3	3.822
10	20	1.604	8.277	31.0	-	31.0	3.745
11	25	1.980	10.22	37.0	-	37.0	3.620
12	30	2.310	11.92	43.2	-	43.2	3.625
13	35	2.65	13.67	48.9	-	48.9	3.577
14	40	3.04	15.69	55.3	-	55.3	3.524
15	45	3.40	17.55	61.0	-	61.0	3.476
16	50	3.82	19.71	68.0	-	68.0	3.450

Particulars of a proposed Electric Freight Railroad from Anaconda to Butte MT.

The length of line would be 28 miles. There would be water at Anaconda, but only a small quantity at Butte. Copper mines are situated at Butte, and the ore would have to be carried over the line to the works at Anaconda where it is treated electrolytically. From 2200 to 3500 tons of ore would be hauled per diem, up a gradient of 0.3% for 22 miles. There is a steeper grade of 1% and over 1.5% at terminus, but the train could be broken for this. Coal – clinker coal – cost $4.00 ~~deal~~ per ton.

The only water power available would be about 75 HP. flow from the Anaconda Works.


Speed curve of 6 mm (½") H.O. armature of copper 100 metres
15 ft. armature
20 ft. armature
STANDARD CROSS SECTION. 10 mm No. 80.
Amperes


Test of Rotating Drill
18th 11th Jan. 92.
Energy in drill
Work expended in lifting weight of drill
Energy in motor running light
Revs. of cam, or cycles of drill, per minute

Speed Test of Hopper-Bell Motor 11th Jan: 92.

The following series was taken about 36 hours later than that on the preceding page:-

No. of Obs.	Lamps	Watts	Amp.	Revs.	Time Revolution	Rpm	Rpm per amp.
					sec.		
1	1	0.075	0.337	2	75.5	2.649 1.59	4.10
2	2	0.160	0.825	4	68.5	5.84 3.50	4.24
3	3	0.260	1.341	6	64.0	9.37 5.62	4.19
4	4	0.340	1.755	8	65.0	12.30 7.38	4.21
5	6	0.507	2.616	12	66.2	18.15 10.89	4.16
6	8	0.696	3.591	15	63.3	23.7 14.22	3.96
7	10	0.873	4.504	20	67.3	29.76 17.86	3.97
8	12	1.04	5.365	21	60	21.0	3.91
9	16	1.358	7.006	27.1	"	27.1	3.87
10	20	1.690	8.720	33	"	33.	3.79
11	25	2.056	10.76	34.8	"	34.8	3.70
12	30	2.52	13.0	44.0	"	44.	3.38
13	35	2.879	14.86	53.2	"	53.2	3.58
14	40	3.200	16.51	59.7	"	59.7	3.62
15	45	3.70	19.09	67.0	"	67.0	3.51
16	50	4.08	21.05	74.0	"	74.0	3.52
17	60	4.64	23.94	83.2	"	83.2	3.48
18	70	5.36	27.66	92.8	"	92.8	3.36
19	80	6.04	31.17	109.0	"	109.0	3.50
20	90	6.88	35.50	112.0	"	112.0	3.16
21	100	7.08	36.54	117.0	"	117.0	3.20
22							

Test of Cam Electric Rock Drill.

The 5 H.P. Sprague motor is geared 4:1 to a Rock-Drill weighing about 70 lbs. A cam on the gear-wheel lifts the drill rod 3" against the pressure of a spiral spring that it compresses. The cam on slipping allows the rod to descend under the accelerating force of gravitation and spring. Two springs were used and following observations made:-

Motor fields separately excited

No. of Obs.	Work	Revs per min. of cam	Volts at motor brushes	Amperes in armature	Energy in Motor armature Watts	Work done against gravity. Watts	Efficiency
1	Disconnected	124	36	2.4	86		
2	" accepting only hammering	168	49	2.45	120		
3		204	65	2.5	162		
4		280	84	2.8	235		
5		348	98	3.0	294		
6		360	102	3.0	306		
7		460	121	3.2	387		
8	Drilling 250 lb. spring	183	53	8	424	284	
9	" 300 "	164	48	10	480	370	240	0.65
10	" " "	200	57.5	11	632	462	330	0.68
11	" " "	240	67	11.5	771	580	400	0.69
12							

4.33.5 dynes one

867 - - at load

0.828 w

48 wire passages

$\frac{0.042}{0.828} = 0.05$ amp - 0.005 I

$48 \times 0.005 \times \varphi \times 1.4 = 867$

$\begin{array}{r} 0.24 \\ 1.4 \\ \hline 96 \\ 24 \\ \hline .336 \end{array}$

$0.336\,\varphi = 867$

$\varphi = 336 \,\overline{)\,867\,0\,)}\, 2500$

$\underline{1950}$

$2.7 \,\overline{)\,2500\,)}\, q$

2500×0.05

12.5

Outline of Magnetic circuit for a Torque Regulating Motor to be constructed. 12th Jan: 92.

The new # 16 S.C. armature there are 8·6 ω of # 14 B.S. wire or 43 lbs. which 200 lbs. of wire are on the field. There are 70 slots on the surface and 2 windings in each slot. There will be 2440 commutator bars for the fields, and 60 slots allowing 4 windings in each slot. Each walls will be of the same thickness as at present, but 2·5 times the space has to be allowed for in each box:- $2·5 \times \frac{12·1}{5·6} = \frac{303}{56}$ lb sq. in. 0·092.

The diameter of polar bore will be 18·4". Allowing 0·15" for lids leaves 18·6" diam: or 58·4" = 0·973" per slot & wall 0·472 gives 0·50" for the bar. & 0·085" deep.

The following are the proposed dimensions:-

Diam: of armature	18·25"
Clearance	0·075"
Diam: of polar bore	18·40"
Depth of lid	0·15"
Diam: of lid circle	18·70"
Depth of bore	1·085"
Diameter of base circle	20·87"
Thickness of field wire	3·2"
Ext: Diam: of field	27·27"
Breadth of box (rectangular)	0·5"
Breadth of wall (min:)	0·47"

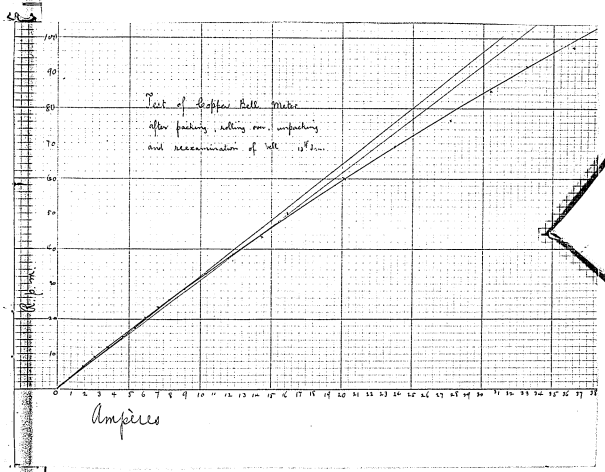
Test of 5 KWT (100 : 1) Transformer 13th Jan: 92.

The transformer was set in its shelter, and kept on full load (100 ℓ) with 12½ volts at secondary terminals commencing at 2½·00 on the 13th inst. The temp: on the shell was observed at hourly intervals as follows:-

No. of Obs.	Time	Hrs. from Start	Temp. on shell °C	Elevation °C	Elevation per hr. °C	Time Hrs. from start	Temp. on shell °C	Temp. on shell Temp. Elevation	Elevation
1	2½.00	0	65F 65°			12.0	168F 76·6	61°	+2
2	1.00		91 33	18	18	13.0	169 76°	61°	0
3	2.0		110 43	28	10	14.0	170 77°	62°	+1
4	3.0		123 50·5	35·5	5·5	15.0	170 77°	62°	+0
5	4.0		128 54	44	8·5	16.0	170 77°	62°	0
6	5.0		135 62·7	47·7	3·7	17.0	169 76·5	61·5	−0·5
7	6.0		143 67	52	4·3	18.0	168 76°	61	−0·5
8	7.0		152 72	57	5·0	19.0	166 75°	60	−1
9	8.0		158 76	61°	4·0	20.0	164 73°	58°	−2
10	9.00		159 69	51°	−7	21.0	166 75°	60	+2
11	10.0		164 73°	58°	+4	22.0	166 75°	60	0
12	11.0		166 74°	59	+1	23.			

The temp: elevations in the above table are somewhat uncertain, as the temp: of the surrounding air was not observed.

Res: of primary @ 22° = 0·829 ω Sec: 0·062 ω
@ 22·ch: = 1·194 0·073 ω
Ratio = 1·4440
Temp: Elevation = 44/0·388 = 113° C. = 125° C. inferred temp of wire


Test of Copper Bell Meter
after packing, rolling out, unpacking
and reexamination of bell 1882...
Volts
Amperes

Test of Copper Bell Motor 11th Jany. 92.

The permanent magnet motor was sealed with a spring stopper, nearly full of mercury. In this condition, with the dial plate and yoke removed, it was packed in a double box, which was then rolled over falling from side to side about one hundred times along the floor of a corridor. It was then unpacked and found to be in good order with none of the mercury dislodged. The copper bell was examined, removed, and replaced. The following measurements were made of its torque and speed.

No. of Obs.	Rad. of Shaft	Weight of Bending	Weight Effect	Total weight	Mean Torque	Mean Current	Torque per amp.	Mean.
1	0.26	1.27	0.1	0.27	0.096	~~2.774~~ 9	0	
2			10	10.27	2.67	~~2.784~~	0.959	
3			20	20.27	5.27	~~5.29~~	0.996	
4			30	30.27	7.87	~~7.95~~	0.990	0.975
5			40	40.27	10.47	10.78	0.971	
6			50	50.27	13.07	13.60	0.961	

It is therefore evident that either the shaking that has been given to the mercury or else the removal and replacing of the cup has altered the torque per amp. by probably affecting the rest of the nickel plated surface.

No. Obs.	Lamps	Obach	Amps.	Time	Revs.	Revs. per minute	Revs. per minute per amp.	
1	1	0.092	0.475	83	2	1.446	3.044	
2	2	0.173	0.893	56	3	3.214	3.599	
3	4	0.353	1.821	64	7	6.562	3.603	
4	6	0.518	2.673	65	10	9.23	3.453	
5	8	0.691	3.566	65	13	12.0	3.365	
6	10	0.886	4.572	67	17	15.22	3.329	
7	12	1.044	5.387	65	19	17.54	3.256	
8	14	1.194	6.161	64	22	20.62	3.347	
9	16	1.380	7.121	60	23.5	23.5	3.300	
10	18	1.532	7.905	"	25.7	25.7	3.251	
11	20	1.704	8.793	"	28.4	28.4	3.23	
12	25	2.12	10.42	"	32.8	32.8	3.148	
13	30	2.49	12.33	"	38.5	38.5	3.122	
14	35	2.77	14.29	"	43.5	43.5	3.044	
15	40	3.14	16.20	"	50.0	50.0	3.086	
16	50	3.92	20.23	"	60	60.	2.966	
17	60	4.60	23.74	"	69.	69.	2.907	
18	70	5.36	27.66	"	76.5	76.5	2.766	
19	80	5.91	30.50	"	85	85.	2.787	
20	90	6.42	33.13	"	92	92.	2.777	
21	100	7.05	36.38	"	97.3	97.3	2.675	

Test of Crocker-Wheeler Arc light circuit Motor fitted with copper shell 1 mm thick

The C.W. Series motor about 1/2 H.P. had a copper cylinder inserted between field pole and armature in the air gap. The dimensions of the shell are 0.029 thickness. Length 5.0. Ext. diam. 9.6. Int. diam. 9.342.

The field of the motor was separately excited, and the armature operated from the 10 volt circuit. The copper shell was free to revolve with a pulley attached, on the armature shaft. A leather cord ran from the shell pulley to a small countershaft pulley which countershaft was coupled by spring with a 1/10 H.P. Paust Motor in the floating dynamometer.

The C.W. Motor armature 0.30" ran at an observed speed, and the energy at brushes was noted. The torque and speed of the Paust driven by the shell was also observed. This gave the proportion of work available at the shell to the work absorbed by the ~~Crocker~~ motor.

No. of Obs.	Current in Shunt	C.W. armt. Amp.	Volts at brushes	Activity on motor shaft watts	Speed of C.W. armt. r.p.m.	Res. of armt.	Activity lost in armt. res.	Efficiency.	
1	1.19	6.14	10.6	65.08	2120	0.30	11.1	54	
2	1.225	6.32	10.6	67	1940		12.0	55	
3	1.250	6.45	10.6	68.37	1580		13.5	55.8	

No. of Obs.	Current in Shunt	C.W. armt.	Volts at brushes	Activity on motor shaft	Speed of C.W. armt. r.p.m.	Res. of armt.	Activity lost in armt. res.	Effort	
1	0.475	2.452	7.60	18.64	1160	0.30	1.80	16.24	
2	1.010	5.212	7.56	39.40	1040		8.15	31.25	
3	1.190	6.141	7.54	46.38	1025		11.31	35.0	
4	1.060	5.47	7.56	41.35	1053		9.00	32.35	
5	1.120	5.779	7.56	42.55	1040		10.02	32.53	
6	1.150	5.935	7.49	44.46	1020		10.57	33.9	

Speed of motor r.p.m.	Speed of Paust r.p.s.	Balance		Moment	6.165 × Moment	Activity in Paust Watts			
11.	50	1.6		80	4.93×10^5	0.54			
3.69	50	19.4		970	5.98×10^6	2.21			
1.76	50	20.4		1020	6.287×10^6	1.11			

The test was repeated on the 18th January with more numerous observations as follows:-

Speed of motor r.p.m.	Speed of Paust r.p.s.	Balance		Moment	6.165 × Moment	Activity in Paust watts			Conditions
0	-	-	-	-	-	-			Running light
—	-	-	-	-	-	-			Cylinder in field only, running
-	-	-	-	-	-	-			Cylinder in field only, field excited
324	5.4	50	@ 3.8	190	1.171×10^6	0.63			Paust light
176	2.93	50	@ 17.6	880	5.425 -	1.57			- full on
99	1.65	50	@ 23.8	1190	7.336 "	1.21			" " " mains S.C.

1000 weighs 16,920 lb. resists 0·0574 = cost = 1·25 per mile $ 10·230

Estimate for Power Transmission. 18th Jany. 92.

1st 1680 HP. delivered at turbine main-shafts.
Transmission is desired to a distance of 20 miles, employing 2 lbs. of underground conduit at each end followed by overhead wire.

1680 HP. = 1253 KWTs.
Efficiency of generator 0·92
Power at generator terminals = 1153 KWTs. Terminal pressure 7000 volts γ = 165
Allowing loss in line at 10% or 700 volts or higher :—

Available Amperes @ 0·92 = Watts eff.		∆ Drop	Actual drop	Res:	Res: per mile 20 miles	B. Mts.	Cost per mile @ 1·25	Total cost.	Resultant pressure	Energy KWTs.
1153	1010	0·146	5	2·12	0·06056	947,600	$ 2,010	$ 140,400 (132,300)	6650	1098
1133	957	0·294	10	4·244	0·12·11	473,800	2005	70,200 (62,110)	6300	1040
1120	903	0·441	15	6·365	0·1816	315,870	1336	46,760 (41,400)	5950	982
1104	850	0·589	20	14·00	0·2424	236,900	1003	35,100 (31,080)	5600	924
1088	797	0·736	25	17·50	0·3031	189,520	802	28,050 (24,860)	5250	866
1077	744	0·884	30	21·00	0·3636	157,900	668	23,380 (20,700)	4900	809

The cost of machine to the public is 40% off 660 per KWT. or 396 per KWT.

	5% drop in line 0·806	10% drop 0·764	15% drop 0·721	20% drop 0·679	25% drop 0·636	30% drop 0·594
Cost of 1250 KWTs. generator	45,000	45,000	45,000	45,000	45,000	45,000
Cost of conductors 0·850 poles 25 =	14,000	14,000	14,000	14,000	14,000	14,000
Cost of 40 miles Cable.	29,000	23,000	22,000	18,000	16,000	13,000
Cost of 31 - overhead off	124,300	62,130	41,400	31,050	24,860	20,700
- - Motors	39,530	37,400	35,300	33,300	31,200	29,180
Total cost.	292,830	191,530	157,700	141,350	131,060	121,800
Cost per KWT. Abbt	$ 290	$ 200	$ 174·60	$ 146·30	$ 116·50	$ 163·60
Cost per HP.	$ 216	$ 149·20	$ 130·30	$ 109·10	$ 122·70	$ 122·10

2nd 4800 HP transmitted 50 miles distance. 4800 HP. at Turbine shafts.
4800 HP. = 3580 KWTs. Efficiency of generator 0·92 = 3293 KWTs. @ 7000 = 470 γ

% Drop	Actual Drop	Res:	Res: per mile 50 miles	B. Mts.	Cost per mile 50	Total cost 51 miles	Pressure at receiving end	Energy at turbine	Available amperes @ 0·939	General Efficiency	Available Energy in HP.
5	350	0·74446	0·013586	4,244,000	$179,340	9,915,000	6650	3426	2876	0·803	3855
10	700	1·4490	0·02708	2,122,000	8,968	457,500	6300	2962	2725	0·761	3652
15	1050	2·2434	0·04061	1,413,000	5,976	304,800	5950	2498	2574	0·719	3450
20	1400	2·9978	0·05413	1,060,000	4,483	228,700	5600	2033	2422	0·677	3246
25	1750	3·7224	0·06767	848,200	3,588	183,000	5250	1568	2271	0·634	3042
30	2100	4·4468	0·08121	706,700	2,986	152,300	4900	1104	2120	0·592	2842

	5% drop in line 0·806	10% drop in line 0·764	15% drop 0·721	20% drop 0·679	25% drop 0·636	30% drop 0·594
Cost of 3293 KWTs. in generator with	$ 118,600	118,600	118,600	118,600	118,600	118,600
Cost of poles 525 miles @ 500	24,000	24,000	24,000	24,000	24,000	24,000
Cost of 40 miles cables	220,000	110,000	88,000	60,000	52,400	44,900
Cost of 51 - overhead conductor	915,000	457,500	304,800	228,700	183,000	152,300
- Motors	112,600	106,700	100,700	94,800	88,840	82,960
	1,390,200	816,800	633,900	526,100	469,840	445,760
Cost per KWT. Abbt	$ 423·40	$ 249·00	$ 246	$ 247·30	$ 246·90	$ 210·30
- - HP. -	$ 289·70	$ 223·70	$ 183·60	$ 162·1	$ 154·40	$ 156·90

1st Model

Mains # 24 B.W.G. hard drawn bare copper wire doubled 4.84 c.m. each = 9.68 c.m. $\frac{0.0210}{2}$ = per foot = 0.0105 = representing 7.33×10^{-5} = per foot on actual plant.

∴ Drop at	A	5.92	X	7.99
	B	5.94	Z	6.30
Feeder ends	C	6.11	not Estimated	6.26
	D	5.23		

Res. between the bus bar by bridge 0.1497 assumed ∴ of lamps if no mains was wanted 0.3996 = calculated from loads.

262.81 amp. through lamps representing 1295 16 c.p. lamps on system

2nd Model Same mains and feeders but with different load.

∴ Drop at	A	10.67	X	12.55
	B	9.82	Z	9.5
	C	11.22	not Estimated	11.67
	D	10.82		

502.41 amp. through lamps representing 2475 16 c.p. lamps on system.

Calculation of the Drop in Pressure over the Trenton 1886 System. 19th Jany.

(7)

A calculation has already been made of this system in Book II at page 119. More complete data is however now supplied both as to conductors and as to the situation of the loads upon them. The following table gives the feeders and mains.

Feeder	Length feet	Outside wire all B.W.G. gauge	Circular mils	R. per foot	Cond. per foot	Total res.	% Conductivity had we obtained	Sizes of conduits at B.W.G.
A	6314	# 5, # 8, # 10	41,209, 27,225, 10,075	1.231×10^{-4}	3273, 2398, 1692, 7174	0.123	97%	# 3
B	695	# 5, # 8, # 10	41,209, 27,225, 10,075	1.497×10^{-4}	3273, 2398, 1692, 7174	0.0804		# 8
C	220	# 12	11,881	8.924×10^{-4}	1117	0.1961		# 12
D	627	# 5, # 8, # 10	41,209, 27,225, 10,075, 78,509	1.137×10^{-4}	4268, 3225, 2537, 9030	0.0712	87%	# 4
Mains		# 20	1010, 1020	7.368×10^{-5}	12370	0.0127		# 4

A map was made on the scale of 25 feet to the inch or 1/300th natural size. The mains were laid off on this map as copper wire (doubled) # 24 B.W.G. hard drawn offering $\frac{0.0105}{2}$ = per foot or just 150 times the resistance of the mains in the actual plant. By this means the resistances on the model between any two points were just half what the actual resistances in Trenton must have been. The contracts to the number of 158, in evidence as having been fulfilled, were examined and the lamps summed and marked off in c.p. on each house. The current in each house was next found assuming every lamp lit by allowing 0.65 amp to each 16 c.p. 105 volts or 0.325 amp. on 3-wire 210 volts = 0.0203 amp. per c.p. The drop in the houses and house leads was neglected, and the load in amperes collected to each pole. A distinction was made however between the loads operated when the plant first started, and those assumed 3 months later.

The resistances corresponding to these loads divided by two, were made up of German silver wire S.cond. 1 paraffin wax, connected across the mains at the proper points. Feeders of copper wire of 0.0390 = 0.0520 = 0.0980 = and 0.0350 = each conductor, were connected or from the station to the proper points of the system. Two Lalande cells in series were then connected through leads to the C.S. bus bar, and two more thick leads from these to the new potentiometer, having 510° of g.s. wire offering a res. of 7.805 = The travelling contact was placed in connection with different points of the system by a stray wire through the H.R. Galvo. The balance gave the ∴ drop on one side of the 3-wire system directly. After the pressure had thus been mapped out completely for the system as first started, the loads were altered to represent the conditions 3 months later, and new readings taken. Finally the mains were altered at the extremes and a third series taken, when one # 24 B.W.G. of the two forming the mains was exchanged for a # 26 B.W.G. = 324 + 404 = 808 c.m. representing 12,1200 c.m. while # 0 B.W.G. is 0.340 and 115,600 c.m.

If a lateral displacement took place in this armature from the centre of 1½" or 0·25 cms, it would alter the centre in ratio of 2 to 2·5. The effect of the field reluctance would be to alter this in ratio of 2·05 to 2·45. Of the 12,100,000 C.G.S. lines issuing from each pair of like poles, 5,611,000 would enter from the far side and 6,489,000 . . . from the near side making the flux densities 4,305 and 5,070 respectively.

The stresses per sq. cm would be 7.378×10^5 10.24×10^5
or 7·54 gms 10·44 gms
1·66 " 2·30 lbs.

The difference in ~~pressure~~ stress = 0·64 lbs per sq. cm.
The total polar area 12,800 " 8192 lbs

(18)

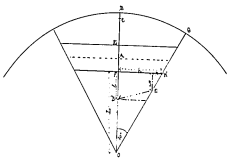
Particulars of a 300-KW.T. multipolar dynamo proposed to be constructed for the N. Y. Elec. Co.

Power 300 KWTs.
Voltage 160
Amps. 1875.
Speed 120 r.p.m. 2 r.p.s.
Poles 10 on each side (5 N and 5 S) 20 polar faces in all.
Estimated weight 28,000 lbs.
Flux through each polar face 6,050,000
Total flux 60,500,000
Cross section of armature core 30 × 19 = 570 sq. cms.
Effective cross. section allowed 0·85 = 484 sq. cms.
Useful flux density in core 12,500
Total useful armature flux = 6,050,000
Polar surface 1280 sq. cms. on each side = 2560 sq. cms.
Air gap (entefer) 2·25 cms. on each side
Clearance 0·6. (0·25")
External diameter of armature core 88" (223·5)
Internal " " 64" (162·6)
Flux density in air gap 4800.
Breadth of armature bar 7·5" = 19·05
Mean length of magnetic cct. in steel magnets 150 cms.
" flux density " " " " 12,500.
" leakage allowed 0·25
Number of ~~bars~~ – 650 for multiple winding
Mean length of bars 42". 106·7 cms.
" cross section " 0·16" = 103 sq. cms.
Resistance between brushes 0·00123 ω.
Drop in armature at full load = 2·34 volts.
Field spools one on each side of armature, about 9" square section
Mean diams. about 48".
Mean length of one turn 170".
Brushes. Four sets, one to each segment.
Commutation on external surface of armature.
Surface speed of commutation 3720' per min.
If this armature were series wound, there would be 154 turns, with a change of shape in cross section.

From these figures the total field flux is 8,064,000 and the mean cross section of field core 640 sq. cms.

Reluct. area of field = $\frac{100}{640} \times 0.0022 = 0.0005156 \times 2 = 103 \times 10^{-3}$
" " armature ½ of this 0·26
" " air gap (entefer) 7·34
9·23

MMF necessary to force 3.025×10^6 lines through this cct = 27.92×10^3 = 27,920
" 22,220 A.T.



On the Cost of Transmitting 1000 HP electrically to a distance of 16 miles

Objections are raised by the intending purchaser to operating generators in series, and the highest potential that the Schenectady Works will attempt at present is 2000 volts.

Allowing 2000 volts at motor terminals or a drop of 1000 volts.

1000 HP at Motor shafts @ 0·92 = 1087 HP. = 811 KWTs @ \$60 = \$ 48,660		48,660
Current at 2000 volts = 405·5		
Resistance of line 2·46 ω.		
If ground can be obtained allow 0·46 ω for same and resistance of line = 2 ω or 0·125 ω per mile = 475,000 c. mils. \$2000 per mile 1½ miles		32,000
If ground cannot be obtained, and return cct is used 32 miles for 2·46 ω = 0·076 ω per mile = 750,000 c. mils \$ 3,172 per mile × 32 miles =	101,504	
Generator 3000 × 405·5 = 1216·5 KWTs @ \$60 =	72,990	72,990
	223,154	153,650

Weight of a brass casting made from a wooden pattern.

The pattern weighed 7 lbs 4½ oz = 7.28 lbs.
" casting " 142 lbs.
" ratio 19.5.

Determination of the conditions for maximum winding space in a hexagonal frame armature.

In the sector of 30° BOC. OA = ½OB, AF = AE are magnetically determined, and BC is mechanically confined. This gives AD = AC. The winding space cross section for the coil is thus $\frac{y+l}{2}(L-x)$ where $y = \frac{x}{2}L$

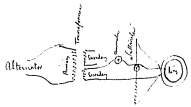
$$\text{Area} = -x^2\frac{L}{2h} + x\frac{L}{2} \quad \text{or} \quad \frac{xl}{2} + \frac{hl}{2}$$

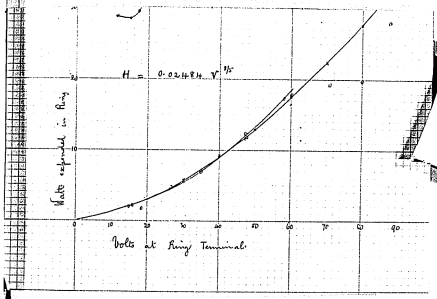
$$\frac{d(\text{area})}{dx} = -\frac{Lx}{h} + \frac{L}{2} \quad \text{or} \quad \frac{l}{2}$$

$$\therefore x = \frac{L-l}{2} \times \frac{h}{L}$$

$$= \frac{h}{2} \cdot \frac{L-l}{L}$$

If l is less than a certain quantity, the best value of y for a maximum area becomes greater than l


Alternator
Transformer
Rectifier
Rectifier
Smoothing Choke
Lamp


H = 0.02484 V^1/2
Watts expended in Ring
Volts at Ring Terminals
0
10
20
30
40
50
60
70
80
90

Hysteresis Test of Nickel Wire Ring

22nd Jan. 32.

A closed Faraday ring was formed of nickel wire diameter 0.0365 0.0247. There were 570 of these turns of wire making 3.955 sq. cms, the area of each wire being 0.00634 sq. cm. The weight of the wire is 225 gms. The int. diam. 18.5 approx. and the ext. diam. 23.5 approx; so that the diameter of the section is roughly 2.5.

The ring was wound with 700 turns of #22 B&S. 0.028" in 7 layers. It was connected up through an ammeter and wattmeter with the secondary coil of a transformer and the power absorbed measured as the pressure increased. Port #3 of the Wattmeter was used.

	Res.	α	τ	Energy in ring	Current	C^2	Ohmic energy	Residual energy (Hysteresis)	Effective p.d.	Energy in gas then $\frac{dE}{dt}$
	1790	2.375×10^{-5}	28.5	1.198	0				12.5	
	2310		38.5	2.11	0.1	0.01	0.033	2.077	16.	
	2260		53.5	1.80	0.1	0.01	0.033	1.767	18.5	
	1850		110.5	4.35	0.15	0.0225	0.075	4.775	26.5	
	1010		83.5	2.004	0		–	2.004	15	
	3055		95	7.18	0.25	0.0625	0.208	6.972	35	0.3
	3160		165.5	12.65	0.35	0.1225	0.407	12.243	47.6	0.7
	4560		169	18.31	0.58	0.3364	1.12	17.19	58	0.74
	4740		204	22.96	1.05	1.103	3.67	19.29	71.2	
	6740		176.5	28.26	1.60	2.56	8.51	19.75	80	
	6010		307	44.10	2.2	4.84	16.1	28.0	88	

A second ring was made up of a larger hank of nickel wire (20 gauge) 0.0359" in diam. The int. diam. of the hank was 18.0, the ext. diam. 24.3. Mean diam 21.15. Mean circ. 66.45 cms. The weight of the ring was 225 gms. The winding was 700 turns of # 21 B&S. 0.032" 0.0246". There were 4160 turns of wire.

The cross section of the wire = 8.142×10^{-4}

" " " " ring = 3.966 sq. cms.

$$\phi = \frac{E/2}{M} = \frac{1.4114\,C}{700\times889.5} = \frac{1.4114\times C\times10^{8}}{0.6227} = 2.27\,C\times10^{8} \text{ in the first test}$$

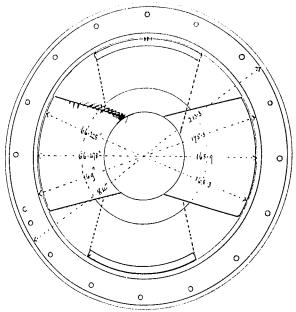
$$\phi = \frac{1.4114\,C}{605\times889.5} = 2.627\,C$$ in the last test see p. 39.

$75.94 \times 3.12 = 237'$

$99.18 \times 1.814 = 180'$

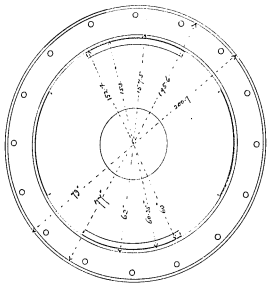
Scale 1/20 th.

Section of 100 KWT machine in plane of revolution.



Electromagnetic Design for a generator of 100 KWTs capacity at a pressure of 10,000 volts cont:

Type	Quadripolar generator Ring
Power of dynamo at brushes	100 KWTs.
E.M.F of dynamo . .	10,000 volts at full load.
E.M.F allowed for	11.000 "
Current at full load	10 amperes.
Number of poles	4
Speed of revolution	172 r.p.m. = 2.867 r.p.s.
Annulus useful flux	7,000,000
Number of turns	$1.1 \times 10^{12} \div (2.867 \times 7 \times 10^{6} \times 2) =$ 27,400. allowed to 26,304
m	0.025
Res: between brushes	25 ω.
" all rounds	400 ω.
Res: per turn	1.46×10^{-3} ω.
Ratio of length of core	2.5
Flux density in core	9000
Useful cross section of core	778 sq. cms.
Space factor	0.85
Actual cross section . .	915 sq. cms.
Depth of core	19.05 (7.5")
Breadth " "	48.03 (18.9")
Annular area . .	55 41.8 − 3739.3 = 1802.5 sq. ins = 11630 sq. cms.
External diameter	213.3 (84") Circ. 670.25 (263.9")
Internal "	175.3 (69") " 550.7 (216.8")
Volume of core	558,700 c.c.
Effective " "	475.000 " "
Mass of iron in core	3706 kgrms = 8170 lbs.
Length of one turn	56.6" (1144 cms) = 4.71'
Res: needed per foot	0.00310 ω @ 100° C. # 16 B.W.G 0.065" d. c. c. 0.078"
Circular mils	4225
" " per amp.	1690
Length of wire on arm	129,100 feet.
Weight " " "	1652 lbs.
Turns per quadrant	6850 . altered for convenience to 6576
Turns per layer	2185 in one circle allowing 80% space.
Layers allowed	12
Depth of winding	0.936"
Bobbin insulation	0.2"
Outlined insulation	0.125"
Clearance	0.125"
Entire	1.390" = 3.5 cms
Polar arc	60°
Polar surface	88 × 48 = 4224 sq. cms
Reluctance of air gap	2×3.5 ÷ (2112) = 3.315 m.m.
Reluctance of armature	90 × 1.2 / 778 = 0.1388 m.m.
MMF for 7,000,000 lines	23200 = 18860 A.T.
Flux density in air gap	3315 useful.
Amp. turns in armature	274,000 / 551 = 497 ÷ 4 = 125
Flux density per cm sq	2644.
Number of bobbins	548 = 137 per quadrant
Winding	Blocks of 4 wire wide × 12 deep to centre.

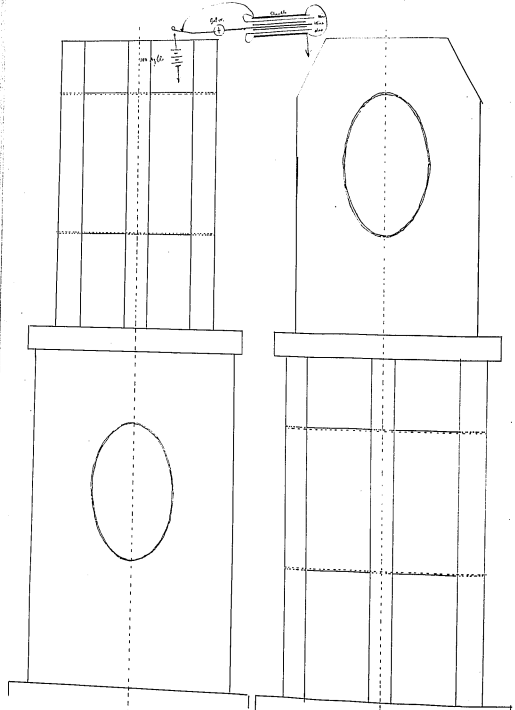


Annular area of armature	= 4971 − 3022 =	1949 sq: cms.
External surface	= 193 π × 52 =	25,000
External -	= 209 π × 52 =	32,670
Total -	=	61,428 sq: cms.
Energy in arm: at load	=	2·5 KWTs.
Hysteresis	=	0·003 × 4 × 4·3 15 × 10^5 × $(9.0 \times 10^{-4})^{1.6}$ × $(10^7)^{1.6}$ = 1·10 × 10^3
	=	1·10 KWTs.
Total energy lost	=	3·60 -
Energy per sq: cms:	=	1/17 = 0·0586
Sq: cms: per watt	=	17.06

Electromagnetic Design for a 100-Kilowatt 10,000 volt Generator or Motor.

Power 100,000 Watts Quadripolar Gramme Ring

P.D. at machine terminals full load	=	10,000 volts. 11,000 allowed for
Current at full load	=	10 amps.
Number of poles	=	4
Speed of revolution	=	286·5 r.p.m. = 4·775 r.p. sec.
Armature useful flux	=	7,000,000
Number of turns needed	=	$1.1 \times 10^{12} \div (4.775 \times 2 \times 7.0 \times 10^6) = 16450$
- - - allowed	=	16,800.
Res: between brushes	=	0.025 m
Res: all round armature	=	25 ω.
Res: per turn	=	400 ω.
		2.381×10^{-2} ω.
Ratio of breadth to depth of core	=	2·5
Flux density in core	=	9000
Useful cross section of core	=	778 sq: cms.
Space factor	=	0·85
Actual cross-section	=	915 sq: cms.
Depth of core	=	19.05 (7.5")
Breadth - -	=	48.03 (18.9")
External diameter of core	=	77" (195.6) = 241.9" circ: 6145 cms
Internal - - -	=	157.5 (62") = 194.8" circ: 4948 -
Annular area of core	=	4656.6 − 3019.1 = 1637.5 sq: cms. 105/sq.
Volume of core	=	707,500 c.c.
Volume of iron in core	=	431,500 c.c.
Mass of iron	=	3266 kgms. = 7420 lbs.
Length of one turn	=	56.6" (144) = 4'7
Resistance of wire per foot	=	1.005065 ω @ 100°C
Total length of wire	=	78960'
Diameter of wire	=	0.0505" #16 B.&S. d.c.c. 6 0.064"
Number of turns in one layer	=	19.75 62 × 0.8 ÷ 0.064 × 3.1416 = 24.35
Number of turns allowed	=	2100 and 7 layers.
Commutator block	=	600 or one to each 28 turns
Armature winding	=	7 wire deep and 4 wide.
Mean volts per turn	=	2.62 or 73.34 per commutator block.
Lineular mile in wire	=	25.81 or 103.2 per ampere at load.
Weight of wire on arm.	=	617.7 lbs.
Clearance	=	0.125"
Internal armature diameter	=	60.25"
Depth of winding	=	8 × 0.064" = 0.512"
Winding internal diameter	=	60.89"
Thickness of body insulation	=	~~61.53~~ 0.235"
Winding external diameter	=	61.53"
Polar face angle	=	60°
Polar surface	=	82.5 × 48 = 3962 sq: cms.
Entefer	=	1.0" = 2.54
Magnetic circuit gap = Pole face	=	2 × 2.54 / 2000 = 2.54 m.m.
Armature segment -	=	0.13 m.m.
Estimated total fld. in ct.	=	2.9 m.m.
MMF for 7,000,000 lns.	=	20,300 = 16,240 Amp Turns.
Flux density in air	=	3500.
Amp turns per cms on arm.	=	42,000 / 500 = 84
Running value	=	41.7.



Full Size Elevation of Dynamometer.

Tests taken at Schenectady 14th January on the Static Capacity of a certain sample of Cable.

14 = wire cable, each wire 0·0403" (0·1023) #18 B.W.G. insulated with dry paper to a thickness of 0·125" (0·3175).

Length 470 feet by rotometer. 100 single cells

Capacity by direct deflection. All wires and sheath grounded, except one tested.

Outside Wire			Inside wires	
#1	226	mm throw	#11	222·8 mm throw
2	227·7		#12	210·8
3	220		#13	215·8
4	226·6		#14	210·5
5	225·8		Mean.	215·0
6	230·3			
7	228·7			
8	228·5			
9	228·3			
10	226·8			
Mean	226·7			

Mean of all wires 223·34
" " lead 13·
" " cable 210·34 div, no leakage

Condenser 0·05 μ 100 cells

0 – 15	218 div	at rate of	1453	per 100
15 – 30	217		1447	
30 – 45	218·5		1457	
45 – 60	222		1481	
60 – 75	220		1467	
75 – 90	219		1460	
90 – 100	164		1440	
	1458·5 div		1458	

$\frac{0.05 \times 210.34}{1458.5}$ = 0·007209 μ absolute mean capacity.

= 0·08095 μ per mile of 5280'.

Data for the new double-dynamometer for transformer tests.

Larger coil 0·9" wide 0·9" deep. Divided into four windings

1st winding) 4 strips of 0·020" thick 0·875" wide one turn on each partition = 2 turns 7,700,000 sq. mils Total length 1·75'

2nd " 1 layer of 2 turns in each partition ~~#16 B.W.G. 0·207~~ or 4 strips of 0·020" thick 0·4" wide two turns on each partition = 4 turns d.c.c. 0·255" = 4 turns 41,000 c. mils 32,000 sq. mils.

3rd " 2 layers of #13 B.W.G. 0·095" d.c.c. 0·108" 7 turns = 14 turns per partition, 28 turns total 9.021 c. mils

4th " 4 layers of #19 B.W.G. 0·042" d.c.c. 0·054" 15 turns = 60 turns per partition 120 turns total 1,764 c. mils

Smaller coil 0·65" wide and 0·7" deep

1st winding 1 layer of 3 turns #9 B.W.G. 0·148 d.c.c. 0·161" = 6 turns in all

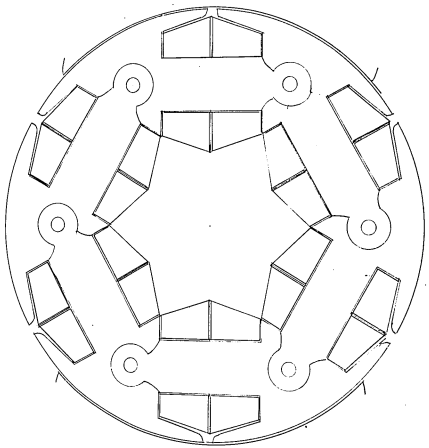
2nd " 2 layers of 7 turns each #15 B.W.G. 0·072" d.c.c. 0·085". 14 turns per partition, 28 in all

3rd " 4 layers of 15 turns each #22 B.W.G. 0·028" d.c.c. 0·040". 60 turns per partition, 120 in all

4th " 8 layers of 27 turns #26 B.W.G. 0·018" d.c.c. 0·021" 216 turns per partition, 432 in all.

000567

Armature of hexagonal type to replace pentagon in 1/16 H.P. field, if latter found unsatisfactory.



Determination of the Dimensions and Winding for a new Hexagonal Composite Frame Armature for 1/16 H.P. Field

Voltage of motor = 120

Speed without load	= 1800 r.p.m.	= 30 per sec.
Number of turns needed on arm.	= 3600 all round	= 600 per double spool 300 per spool
Winding space, dimensions (inches)	= 0.71" × ½(0.55 + 0.34)	= 0.316 sq. ins.
Available winding space	= 0.316 × 0.80	= 0.253 sq. ins.
Space per wire	= 8.42×10^{-4} sq. ins.	
Diam. of wire	= 0.029" or 0.022"	# 24 B.W.G. s.c.c.
Length of one turn	= 5"	= 0.42'
Total length of wire	= 1512'	
" weight	= 2.22 lbs.	
" resistance	= 32.28 ω @ 20°C,	36.92 ω @ 60°C, 41.58 ω @ 100°C
" " between brushes	= 8.07 ω	9.23 ω 10.4 ω
Number of commutator bars	= 24.	
Current at full load	= 1.6 amp.	
Drop at full load	= 1.89 volts. cool,	14.77 volts warm, 16.64 ω hot.

Voltage of motor 500

Speed without load	= 1800 r.p.m.	= 30 per sec.
Number of turns needed on arm.	= 16,500	
Number on each spool	= 2750 or 1,375 on each half spool.	
Available winding space	= 0.253 sq. ins.	
" " " per turn	= 2.80×10^{-4} sq. ins.	
Diameter of wire	= 0.010" # 31 B.W.G. silk cond. to 0.013"	
Length of mean turn	= 5"	= 0.42'
Total length of wire	= 6930'00	= 1155' per spool = 577.5' per half.
" weight	= 2.10 lbs	= 0.35 lb. = 0.175 lb.
" resistance cool 20°C	= 71.5 ω	= 11.92 ω = 5.96 ω
" " between brushes cool	= 17.88 ω	= 2.98 ω = 1.49 ω
" " warm 60°C	= 81.8 ω	= 13.63 ω = 6.82 ω
" " between brushes	= 20.45 ω	= 3.41 ω = 1.70 ω

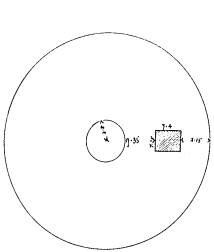
Commutator bars = 48.

Tests of Copper Bell Motor

Date	Amps from Start	Mean torque per amp.	ft pds. over.	Revs. per min. per amp.	Frictional Torque	Conditions
		cwt. foot			cwt foot	
4th January 92.	47	1.371	0.9×15^2	4.6 (?)	0.463	Same as before tabulated. Book V p.112.
7th . .	50	0.545				Current supplied to armature, bell as field only
– . .	50	0.99		6.3		Current supplied by nickel electrodes in cover and armature ring nickelled on bell
9th . .	52	1.160		3.7		Nickel electrodes in cover and upper surface of bell nickel plated, disc commutator
11th . .	54			3.9		Same
14th . .	57	0.975	0.6 "	3.2		After removing bell, finishing armature tight, and nothing but cover leaving frame as it stands
16th . .	59	1.290	1.4 "	4.4	0.23	After replacing armature by amalgam on nickel plate of bell
19th . .	61	1.288	0.8 "	4.4	0.56	After replacing bell and replacing it
23rd . .	66	1.304	1.3 "	4.3	0.20	– – – – – –
25th . .	68	1.293	0.4 "	4.3	0.12	– – – – – –
2nd Feby.	78	1.279	0.5 "	4.3	0.07	1st Feby. armature with amalgam amalgam 2nd upper electrode in cover

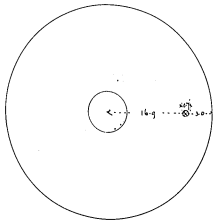
Experiments on Foucault currents set up in a large revolving copper arago disk driven by a motor between the poles of a powerful magnet.

A disk of copper 37·8 (14·875") in diameter and 0·815 thick was turned up true in the lathe, and clamped on a motor shaft (10 KWT) firmly with its plane perpendicular to the axis. The current taken by the motor in its armature, with the field separately excited, was about ten amperes and nearly independent of the speed. This represents a steady normal torque of 90 megalpne.c.cms. or 92·1 kgms. cms. The copper disk was driven at varied speeds between the poles of the large experimental electromagnet. The position of the poles, their separating distance, together with the currents and emfs were observed as follows:—



No. of Obs.	Pole pieces	Distance between poles cms.	Current in magnet coils amp.	Speed of motor r.p.m.		Current in motor amp.	Current in motor beyond point of motor amp.	P.d. at motor terms volts	Work in motor watts	Torque at disk megalpne. deductions
	7·4×7·4	1·240	12·5							
1				34	0·5·6	16	6	3·24	19·4	5·513
2				46	0·7·6	19	9	4·38	39·4	8·24
3				60	1·0·0	24	14	5·72	80·1	12·8
4				76	1·2·6	29	19	7·25	138·	17·3
5				112	1·8·6	36	26	10·68	278	23·7
6				240	4·0	49	39	23	907	36·1
7				1100	18·3	32	22	105	2310	20·1

Repeated same measurements using conical poles instead of flat headed ones. Mean flux density 4000, total flux 12,600.



No. of Obs.	Pole pieces	Dist. between poles cms.	Current in magnet coils amp.	Speed of motor r.p.m.		Current in motor Amp.	Current in motor beyond point of motor amp.	p.d. at motor terms volts	Work in motor watts	Torque at disk megalpne. deductions
1	Conical	1·2	12·5	12·4	20·6	12·95	12	7	41·6	81	6·25
2				2×95·6	51·593	20·12	15	10	17·8	178	8·9
3				2×116·4	61·94	24·37	17·5	12·5	21·7	293	12·0
4				2×168·4	82·81	35·3	24·0	15·0	31·3	470	13·3
5				2×305·	125·08	62·8	24·0	15·0	58	870	13·64
6				2×457·5	177·63	95·98	18·5	13·5	85	1150	12·0
7				887	114·8	93·28	15·5	13·5	83	1120	12·0
8				1096	15·25	114·7	16·	12	102	1326	11·6
9				1244	20·73	130·3	15	12	116	1508	11·6

The torque therefore diminishes after a certain maximum has been reached depending on the magnetic field and its phase relation to the disk. In this instance the pointed poles produced the greatest torque at 3 cms. from the edge, and the field was much distorted by the currents induced in the copper. A nail resting on the pole piece with its head elevated its far end when the disk was driven rapidly through the field indicating the dispersion of the resultant field. A.B represent in the diagram the position assumed in diving by a nail that normally rests flat on the pole piece.

Synopsis of Data relating to Transformers now built.

17,000 alt per min: 141.7 ~ per sec. p. = 890.14

	100 Watt	500 Watt	1 KWT.	2 KWT.	5 KWT.			
Dimensions Length	20.45 8.0"	25.13 9.9"	27.21 10.7"	33.66 13.25"	42.0 16.5"			
Bow breadth transverse	7.81 2.8"	8.08 3.15"	7.75 3.05"	5.72 2.25"	9.33 3.75"			
Height ([illegible])	6.67 2.63"	9.02 3.55"	9.43 3.71"	10.24 4.03"	16.0 6.5"			
- Lid	3.81 1.5"	4.44 1.75"	4.44 1.75"	2.08 2.0	6.16 2.25"			
- total	10.48 4.13"	13.46 5.30"	9.3 3.66"	12.3 4.85"	22.1 8.7"			
Core breadth long	7.11 2.8"	8.0 3.15"	8.0 3.15"	8.0 3.15"	10.01 3.94"			
Side wall breadth	3.81 1.5"	4.44 1.75"	9.3 3.66"	5.08 2.0"	6.0 2.36"			
Base	3.81 1.5"	4.72 1.86"	9.3 3.66"	4.6 1.81"	6.0 2.36"			
Winding space	(2.857)" (1.125")	(4.44/2) (1.75/2)	16 (5.04)"	(5.08)" (2.0")	(14×) (5.5") (3.283 d)	(16.0)" (3.94")	2.36"	
Volume of iron	1300 cc.	2180 cc.	2720 cc.	3600 cc.	6800 cc.			
Mass of iron	10.18 lb 4.6 kg	16.56 lb 7.5 kg	19.14 lb 8.68 kg	25.02 lb 11.35 kg	53 lb 24 kg			
Breadth over coils	12.8 5.05"	16.45" 6.5"	19.0 7.5"	23.5 9.25"	30.0 11.82"			
Mass of copper	0.50 lb 0.227 kg	2.5 lb 1.13 kg	5.25 lb 2.38 kg	11.5 lb 5.22 kg	27 lb 12.25 kg	84.5 lb 38.3 kg	62 lb 28 kg	
Total mass	11.1 lb 5.03 kg	20.4 lb 9.25 kg	27.4 lb 12.43 kg	36.5 lb 16.57 kg	80.5 lb 36.5 kg	137.9 lb 62.5 kg		
Watts per unit mass	9.01 4.08	24.5 11.1	36 16	54.4 24.7	62.1 28.2			
Winding Turns of primary	700	700	700	700	400			
- - secondary	168	168	168	168	96			
Primary wire (1000 v)	0.0394 cm (0.015") 0.7 mm (0.028")	0.254 cm (0.1") 0.254 cm	0.318 cm (0.125") 0.318 cm	0.508 cm (0.2") 0.508 cm (0.2")	0.762 cm (0.3") 0.777 cm (0.306")	0.762 cm (0.3") 0.762 cm (0.3")		
Secondary wire (200 v)	0.254 cm (0.1") 0.254 cm (0.1")	0.508 cm (0.2") 0.5 cm	0.762 cm (0.3") 0.762 cm	0.762 cm (0.3") 0.762 cm (0.3")	0.762 cm (0.3") 0.762 cm (0.3")	0.762 cm (0.3") 0.762 cm (0.3")		
Space coefficient	1.7	1.4	1.32	1.33	1.4			
Res: of primary	20°C 68°C 104°F 20.7 Ω 26.4 Ω 4.75 Ω	20°C 68°C 104°F 10.4 Ω 13.2 Ω 2.4 Ω	20°C 68°C 104°F 7.4 Ω 9.4 Ω 1.6 Ω	20° 68° 104° 3.2 Ω 4.1 Ω 0.8 Ω	20° 68° 104° 0.75 Ω 0.95 Ω 0.17 Ω			
- - secondary	0.96 Ω 1.09 Ω 1.18 Ω	0.24 Ω 0.31 Ω 0.42 Ω	0.13 Ω 0.17 Ω 0.21 Ω	0.04 Ω 0.06 Ω 0.08 Ω	0.01 Ω 0.02 Ω 0.02 Ω			
Primary Current no load		0.1	0.1	0.2	0.45			
- - full -		0.63	1.2	2.15	5.5 amp			
Secondary - - -	1 amp	2.25	4.5	8.6	21			
Drop at secondary terms full load		2.66	3.75	4.0	5.5			
- in secondary due to primary		1.46	1.2	1.0	0.67			
- - - - - - resistance		1.2	1.1	1.2	0.87			
- - - - - - leakage		0.	1.65	1.5	4.0			
Loss of power in primary, no load		7.65	50	130	280			
Efficiency at ¼ load		0.64	0.83	0.78	0.83			
" " ½ "		0.77	0.90	0.89	0.89			
" " ¾ "		0.77	0.925	0.92	0.91			
" " full "		0.52	0.95	0.94	0.94			
Ohmic loss of power full load		12 w	23 w	53 w	69 w.			
Surface of iron	200 cm²	1200 cm²	1355 cm²	1994 cm²	2660 cm²			
Cross section of core (min)	20.5	64	62	64	95			
Effective - - -	26.7	59.5	57.7	59.5	82			
Maximum flux	26,500	26,500	32,500	26,500	39,400			
- - density	3,800	3,800	3,900	3,800	4,900			
E/A of mag: ckt:	0.56	0.234	0.583	0.68	0.57			
Surface of iron per watt full load		15 cm²	2.26 cm²	1.33 cm²	8.88 cm²			
Weight of shell					114 lb.			
Ratio of copper mass to total mass	0.0287	0.1226	0.192	0.240	0.316			

	28th Dec. 91.	28th Jan 92	d
#1	1.334×10^{-3}	1.337×10^{-3}	1.345×10^{-3}
			1.328
			1.329
#2	1.421×10^{-4}	1.417×10^{-4}	1.417×10^{-4}
			1.407
			1.427
#3	2.375×10^{-5}	2.317×10^{-5}	2.326×10^{-5}
		2.394	2.391×10^{-5}
			2.235×10^{-5}
#4	8.314×10^{-6}	8.570×10^{-6}	8.652×10^{-6}
			8.314
			8.558
			8.634

Winding of a 2 . KWT Transformer for 10,000 volts.

This is the no 2 (a) 2 KWT transformer that was discarded as a model and whose description is to be found with an outline of dimensions on p. 68. Book V.

Effective Primary voltage = 1000
- Secondary - = 10,000

Primary current at no load = 0.2 amp.
- - - full . = 2.2 .
Secondary - - - = 0.20 .

Primary winding = 450 turns of # 16 B.W.G. 0.065" d.c.c to 0.076" in two coils of 225 turns each, above and below the secondary.

Secondary - = 4500 turns of # 24 B.W.G. 0.022" d.c.c. to 0.0230" in one coil. 60 turns in winding layer, 70.5 layers. Insulation 0.2" round centre, 0.175" above and below and 0.175" on outside. Coil 2.11" wide × 2.975" high.

Length of mean turn = 2.25'
" " primary = 1013 feet
" " secondary = 10,120 "
Weight - primary = 13 lbs.
- - secondary = 9.94 -
Resistance - primary = 2.476 - @ 20°C , 2.831 @ 60°C 3.189 - @ 100°C
- - secondary = 32.29 ω " " 36.93 ω - - 41.6 ω - -
Drop in primary at load = 5.45 volt " " 6.23 volt . . 7.0 - -
- - secondary . . = 64.6 . . . 73.9 - - - 83.2 . -
Total weight of copper = 23 lbs.

Recalibration of Kohlrausch Dynamometer Wattmeter

Jan 28th

The dynamometer was recalibrated by resistances and potentiometer as follows

No.	Bench. amp	P.D. across 18°C volts	Amp. by Bench	Amp. by Potent.	Res. in amp. cct.	P.D. across high res. in amp. cct.	Volts at mains	Current in amp. cct by reflection	Current in amp. cct by potent.	Ce.	T
1	2.26	1.217	11.67	12.17	76350	0.8033	122.6	0.01606	0.01613	0.1963	146
2	2.80	1.519	14.448	15.19	3670	1.5754	122.6	0.03211	0.03163	0.50214 / 0.26805	426
3	1.67	0.885	8.677	8.85	37500	1.6377	122.4	0.03264	0.03288	0.2911	219
4	0.188	0.9750 / 1.00	0.970	0.975	37200	1.655	123.2	0.033112	0.033323	0.03244	228.6
5	0.588	0.303 / 0.32	3.034	3.030	8000	0.7727	123.3	0.015443	0.01552	0.04708	335
6	0.245	0.1267	1.264	1.267	7855	0.7801	123.1	0.01567	0.01567	0.019734	137
7	0.096	0.1274	0.4744	0.452	7635	0.8103	123.3	0.01615	0.01627	0.007356	317.5
8	0.033	0.179	0.170	0.179	7595	0.8180	122.8	0.01617	0.01643	0.002941	433.0
9	0.032	0.1782	0.1691	0.1782	3770	1.6335	122.3	0.03244	0.03280	0.00646	252.6
10	0.080	0.4121	0.4128	0.4231	18420	0.6332	123	0.00646	0.00691	0.002799	323.5
11	0.035	0.1761	0.1806	0.1761	18,270	0.3395	123.3	0.00649	0.00687	0.001200	140.5
12	0.015	0.0761	0.0774	0.0761	8,395	0.7343	123.3	0.01469	0.01475	0.001122	132.7
13	0.035	0.1767	0.1806	0.1767	8,105	0.7674	124.0	0.01534	0.01542	0.002724	315.5

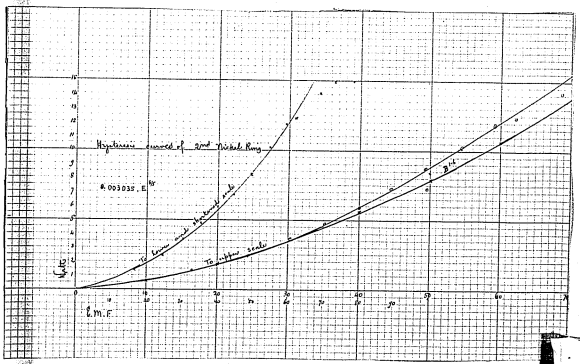
Test of Second Nickel-Wire Ring for Hysteresis.

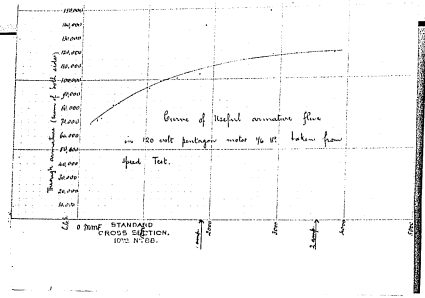
Jan. 23th

The following wattmeter readings were taken with the nickel wire ring mentioned on page 20.

Res. 24. mean 1.92 coil.

Theof No.	R	α	r	Effective f.d. (volts) on coil	I	I²	Kr	Power in coil	Power in Surf. coil	Primary Power in ctr	Net power
1	1057	2.365×10^{-5}	124°	24.5	0		1.31×10^{5}	3.098	0.57		2.43
2	1170		57	16.5	0		6.668×10^{5}	1.577	0.244		1.34
3	2378		71.5	30.25	0.1	0.01	1.701×10^{5}	4.022	0.39	0.02	3.61
4	2331		95.5	35.25	0.1	0.01	2.227 -	5.267	0.53	0.02	4.72
5	2338		120.5	03 40.25 20	0.15	0.0225	2.818 -	6.664	0.69	0.050	5.92
6	2368		146.5	00 45 24	0.2	0.04	3.469 -	8.202	0.86	0.08	7.26
7	2668		155.5	06 50 44	0.3	0.09	4.1148 -	9.810	0.944	0.18	8.69
8	2908		167	03 55.2 245	0.34	0.1156	4.857 -	11.449	1.05	0.23	10.21
9	3278		171	05 60.24 294	0.42	0.1764	5.605 -	13.246	1.11	0.35	11.8
10	3178		188	10 63.2 422	0.5	0.25	5.976 -	14.13	1.26	0.5	12.37
11	3708		188	05 70.2 487	0.74	0.5476	6.970 -	16.469	1.33	1.1	14.06
12	3958		193.5	09 74.8 749	0.93	1.865	7.660 -	18.121	1.341	1.73	14.98
13	3628		242	25 80.5 719	1.3	1.69	8.780 -	20.77	1.79	3.38	15.6
14	3838		258	34 84.5 114	1.72	2.96	9.982 -	23.162	1.92	5.92	15.58
15	3268		335	43 90.5 144	2.15?	4.62	10.95 -	25.90	2.51	9.24	14.15





Test of 1/6 H.P. motors on first completion 26th. Jany 22.

Weight of motors without fans 24 lbs.

Resistance of 500 volt armature 135 ω, Resistance of 120 volt. arm: 60 ω
" " " " field 279 " " " " field 10 ω
" " " " field + arm: 414 ω " " " field + arm: 150 ω.

Armature windings as per specification see Book V. p 133

Field windings 500 volt fields each spool 29 ⅓ layers of 120 turns + 50 turns in last layer. Total number of turns on both spools 7,060

120 volt: field each spool 13 layers 53 turns. Total number of turns on both spools 1378

Diameter of 120 field over binding cord 7.15 = 2.8"
" " 500 " " " 6.75 = 2.65"

Magnetic Test of 120 volt motor.

Test No.	Current on Stack	Field Amp	MMF in circuit	Current in armature	P.D. at armature	Drop in armature	E.M.F. of armature	Speed R.p.m	R.p.s	Ratio of p.m.f. with & without field per R.p.s	Useful flux	ρ
1	0.270	1.554	1878	0.62	50	3.6	46.4	637	10.62	4.37	136,500	1.376 x10⁻²
2	0.315	1.625	2215	"	50	"	"	588	9.8	4.734	148,000	1.492 "
3	0.517	2.668	4622	0.7	49.5	"	45.9	541	9.02	5.087	159,000	2.907 "
4	0.529	4.278	7410	"	49.5	"	"	527	8.78	5.227	163,400	4.535 "
5	0.409	2.110	3655	"	48.5	"	44.9	542	9.03	4.97	155,300	2.354 "
6	0.355	1.832	3174	"	49.5	"	45.9	566	9.43	4.866	152,100	2.087 "
7	0.360	1.858	3218	"	48.5	"	44.9	715	11.92	3.767	117,700	2.734 "
8	0.411	2.121	3674	"	47	"	43.4	695	11.58	3.748	117,100	3.138 "
9	0.322	1.662	2879	"	47	"	"	695	11.58	3.748	117,100	2.457 "
10	0.425	2.193	3799	"	47	"	"	683	11.38	3.748	117,100	3.245 "
11	0.272	1.404	2432	"	46.7	"	43.1	768	11.8	3.653	114,200	3.327 "
12	0.200	1.032	1787	"	46	"	42.4	761	12.68	3.345	104,500	1.710 "
13	0.161	0.831	1440	0.7	46.5	4.2	42.3	782	13.03	3.246	101,400	1.420 "
14	0.134	0.691	1197	"	48	"	43.8	827	13.78	3.178	99,300	1.286 "
15	0.115	0.593	1027	"	47.2	"	43.0	854	14.23	3.021	94,400	1.088 "
16	0.086	0.444	769	"	47.5	"	43.3	903	15.05	2.877	89,900	0.855 "
17	0.064	0.332	575	"	47.5	"	43.3	980	16.33	2.651	82,830	0.694 "
18	0.055	0.284	492	0.75	48	4.5	43.5	992	16.53	2.632	82,240	0.598 "
19	0.034	0.175	303	0.8	48	4.8	43.2	1119	18.65	2.316	72,370	0.419 "
20	0.028	0.144	249	0.840	48	4.9	43.1	1150	19.16	2.249	70,280	0.354 "
21	0.021	0.108	187	0.870	47.5	4.9	42.6	1150	19.16	2.224	69,500	0.269 "

The airgap is 0.075, 0.028" and the length of pole face 12.5
The breadth of the armature 2.1, the pole area 26.25 sq cms.
Calculated reluctance $\frac{0.15}{26.25}$ = 5.7 m.w.

Synopsis of Data for the Edison slow speed Motors.

	100 v.				1 KWT	500 v.				1 KWT
	1/16 HP 1/8 volts	1/8 HP				1/16 HP	1/8 HP			
Extreme diam of armature	5.675"	6.125"			7.5"	5.675"	6.125"			7.5"
Number of segments	4	6				4	6			
Core breadth	0.625"	0.75"			1.75"	0.625"	0.75"			1.75"
Core depth	0.625"	0.75"			1"	0.625"	0.75"			1"
Cross section	2.5	2.25	2.13		1.75	2.5	2.25	2.13		1.75
" " effective	2.13					2.13				
Weight of iron in core	2lb 11oz					2lb 11oz				
Polar bore	5.775"				7.55"	5.775"				7.55"
Entrefer	0.05"				1.05"	0.05"				0.015"
Length of polar face										
Polar effective surface										
Number of spools	4					4	6			
Number of commutator bars	16	24			36	32	48			72
Number of turns on arm	6000	3,000			1332	21,600	15,000			444.52
Turns per commutator bar	375	125			34	675	312			62
Gauge of wire on arm	#27 B.W.G.	#30 B.W.G.			#18 B.W.G.	#33 B.W.G.	#30 B.W.G.			#25 B.W.G.
Diameter of bare + cond. wire	0.02" 0.015"	0.015"			0.04" 0.03"	0.009" 0.01"	0.015" 0.01"			0.025" 0.021"
Resistance of armature	2.2 and 2.2 hot				1.01 hot	3.2 and				2.2 hot
Full load current	1 amp.	1.5			8.5	0.32 amp	0.4			2.1
Drop in armature	25 volts				8.5 v	75 v				16.0
Energy in armature at full load	25 watts				72 w	18 w				9.2
Weight of wire on arm	11lb 12 oz					1.2 lb				
Length " " "	2080'									
Weight of armature										
Diameter of field cores	1.9" 3.6				2.8"	1.9" 3.6				2.8"
Cross section " " "	10	2.25	1.5	2		10	2.25	1.5		
Winding diameter	1.45"					1.45"				
External "	2.1"				4.7"					4.7"
Weight of field wire	1lb 12 oz					1.25 lb				
Diameter of field wire (bare / cond.)	0.015" 0.025"					0.015" 0.025"	0.02" 0.03"			
Number of layers	2.3									
Length " " "										
Resistance " " "	39 and 2.2 hot					1.2 and	1.2			
Armature flux	87,000	12,000			400,000 lines 350,000 lines	87,000	12,000			400,000 lines 350,000 lines
" " density	17,000	12,000				17,000	12,000			
Leakage factor for field cores	1.9				1.6 full load	1.9				1.6 full load
Speed light	1450	1500			1500	2000	1500			1600
Speed at full load	1000				1250	1390	1000			1400
Hysteresis in armature						11				
Current at full load	1 amp				8.5	1.25				2.1
Commutator off	0.4					0.12				
Electrical loss of power	6.6					4.4				
Mechanical friction	25 watts					25				
MMF	2800									
Reluctance										
Entrefferrings of field spools	1.7"				6.6"	1.7"				6.6"
Current in field at no load	1 amp				8.5	1.25				2.1
" " " full	1 amp				8.5	0.25				2.1
Energy	20 watts					26				
Weight of machine	20 lbs.	2 lbs			113 lbs	30 lbs.	2 lbs			113 lbs.

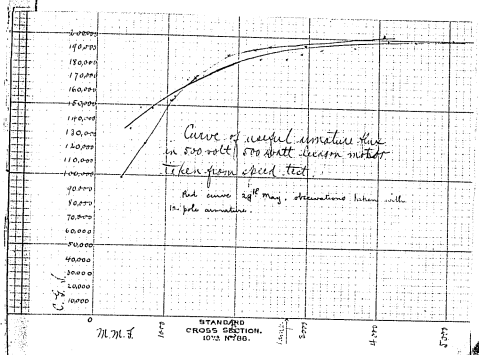
Corresponding Data for 120 volt Machine

Power	=	500 volt 500 watt		
EMF at terminals	=	120 volts		
Current at full load	=	4·2 / 0·7 = 6		
Speed running light	=	1700 r.p.m. = 28·3 r.p.s.		
Armature flux	=	200,000		
Number of wire all round	=	~~2100~~ 2112		
Number of commutator bars	=	24		
Number of segments	=	6		
" " sports	=	12		
Number of turns per sport	=	177 say 176		
" " " per bar	=	88		
Winding space per sport	=	0·3655 sq. in.		
Effective "	=	0·311 " "		
" space per turn	=	17.67×10^{-4}		
Diameter of covered wire	=	0·042"		
" " bare wire	=	0·035"	# 20 B.W.G. s.c.c.	
Mean length of one turn	=	0·54'		
Total length on armature	=	1121'		
" weight " "	=	4·23 lbs.		
resistance of armature	=	2·4 ω @ 20°C.	2·75 ω @ 60°C.	3.1 ω @ 100°C.
Estimated drop in armature at load	=	14·4 volts	16·5 volts	18·6 volts
" " activity lost in armature	=	86·4 watts	99 watts	111.6 watts
Volume of iron in armature core	=	214 g.s. c.i.		
Hysteresis	=	48.5 watts. $[200 \{(17000)^{1.6} \times 0.00333 \times 28.3\}] = 0.0597 \times 9.46 \times 10^{-10} \times 2140$		
Field winding Series	=	3·8 lbs of # 17 B.W.G.	0·055" s.c.c.	& 0·064"
Resistance of field	=	1·05 ω @ 20°C	1·204 ω @ 60°C.	1·36 ω @ 100°C.
Drop in field at load	=	6·3 v.	7·2 v.	8·2 v.
Energy	=	38 w	44·4 w	49 w
Interflange	=	5·0"		
Turns per layer	=	68		
Layers	=	5·2		
Depth of winding	=	0·33"		
Length of wire	=	340'		
Mean length of one turn	=	0·73		
Total number of turns	=	550		

Armature MPD across air gap (max) $= \frac{2112}{4} \times \frac{6}{2} \times \frac{1}{88} = 2000$ ampere.

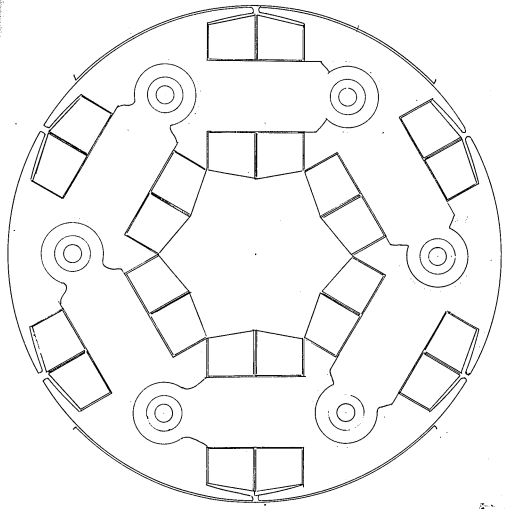
Pole MPD " " $= 0.075 \times 5500 = 412.5$

$\sigma = 0.2$ appx.



500 - Watt Motor

Full - sized section of Armature through plane of plates.



Dimensions and Design for a 500. Watt Motor

Power = 500 Watts

E.M.F. at terminals = 500 volts Current @ 0.79 = 1.267

Speed running light (shunt) = 1700 r.p.m = 28.3 r.p.s.

Armature flux = 200,000

Number of wires all round = 8818 say 8640

Number of segments = 6

Number of spools = 12

Number of commutator bars = 48

Number of turns per spool = 735 say 720

" " " per center bar = 180.

External diameter of arm. = 7.0" (17.78)

Radius of coils centre to = 2.25"

Radius of tie-bolt centre = 2.6"

Winding space section on spool = 0.63" × 0.58" = 0.3655 sq. in.

Effective " allowed = 0.85 × 0.3655 = 0.318 sq. in.

Space per turn = 0.311 ÷ 720 = 4.314 × 10⁻⁴ sq. in.

Cond. Diameter of turn = 0.0208"

" " wire = 0.018" # 26 B.W.G. d.s.c.c. 0.021"

Mean length of one turn = 6.5" = 0.54'

Total length on armature = 4667'

" weight of wire . . = 4.6 lbs. (Actual Weight as constructed 4 lbs.)

" resistance between brushes = 37.22 @ 20°C. 42.57 @ 60°C. 47.95 @ 100°C.
16.72 actual

Estimated drop in arm. = 53.22 volts . . 60.87 volts . . 68.5 volts . .

" Energy lost in arm = 76.1 watts . . 87.0 watts . . 98.0 watts . .

Surface of iron (without teeth) = 22.7 sq. ins. = 136.2 sq. cms. on armature.

Thickness of iron = 2.5 cms. 0.98"

Mass of iron in armature = 28.6 lbs. 12.66 kgms.

Cross section of armature = 6.25 sq. cms. say 6. effective.

Flux density in " = 16,670

Estimated hysteresis = 18 watts

Polar angle = 93°

Length of polar arc = 14.3

Entefer or clearance = 1/32" 0.08

Air gap reluctance (total) = 2 × 0.08 ÷ 36 = 0.16/36 = 4.4 m.h.

Pole surface = 36.0 sq. cms

Armature reluctance = 12 cm. /5.1 × 3.5 × 10⁻³ = 7 × 10⁻³

Field " = 40 cm /10 × 2 × 10⁻³ = 8 × 10⁻³

Total estimated reluctance = 19.4 m.h. say 20

Exciting power needed = 388 4,000 for full flux

Amp. turns " = 3,200 " "

Leakage coefficient = 2.0

Flux allowed through field = 400,000 at full load.

Flux density = 15,670

Cross section " = 26 sq. cms. = 5.53 cms. diam.

Diameter of field core = 2.45" say 2.250" = 5.72 cm = 2570 sq. cm = 15,600

Interpolar = 5.0"

Mean diam. of winding = 2.75" inc. = 8.64" = 0.72'

Total number of turns = 3200 ÷ 5/3 = 6400/3 = 2130.

" length = 1534'

Resistance allowed = 19.44 @ 60°C. = 10.87 × 10⁻³ ω per foot

Series winding

Diameter of wire of field = 0.028" s.c.c. 0.0289" # 22 B.W.G.

Resistance " " " = 20.9 @ 20°C. 23.6 @ 60°C 26.9 @ 100°C.

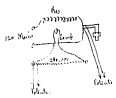
Drop in " at full load = 35.9 volts . . . 33.0 volts . . . 37.2 volts . . .

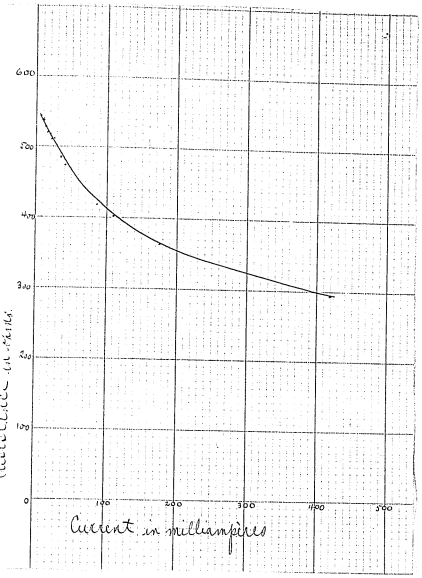
Energy " " " = 44.9 watts . . . 49.2 watts . . 55.9 watts . . .

Weight of wire . . . = 3.95 lbs.

Turns in one layer = 140

Layers = 15 Depth of winding 0.58".




600
500
400
300
200
100
0
100
200
300
400
500
Current in milliamperes

Measurement of the resistance of a 16 c.p. lamp at different current strengths passing through it. Feb. 3rd

An ordinary 16 c.p. lamp marked for 119 volts. Bamboo filament, was tested for resistance by inserting a larger adjustable resistance between it and the 120 volt mains, while measuring pressures with a voltmeter.

No. of Obs.	Current milliamperes	Potentiometer 210,000	Volts on lamp.	Res. of lamp.	Potr reading on res.	
1	6.70	10,000	3.639	543 ω	0.2733	
2	10.2	"	5.484	537	0.2577	
3	13.5	"	7.121	528	0.3391	
4	17.3	"	9.015	520	0.4293	
5	20.3	"	10.525	518	0.5012	
6	22.1	"	11.264	510	0.5364	
7	26.7	"	13.610	511	0.6481	
8	35.5	"	17.182	484	0.8182	
9	41.5	"	19.646	473	0.9355	
10	86.4	"	36.21	419	1.7243	
11	109.9	5000 ω	44.100	401	1.0500	
12	174.6	"	63.302	363	1.5072	
13	419	3000 ω	122.395	292	1.7485	

Particulars observed at the Mc Elraine Execution by Electricity

11. 10. 00

Mr. Elraine entered room

1st contact between jars holding brine with hand immersed (current passing from hand to hand) 11. 11. 49 } 50 secs.
11. 12. 39

1600 volt 2.0 amp 2.1 27 30 finally 3.1 5.6 ω

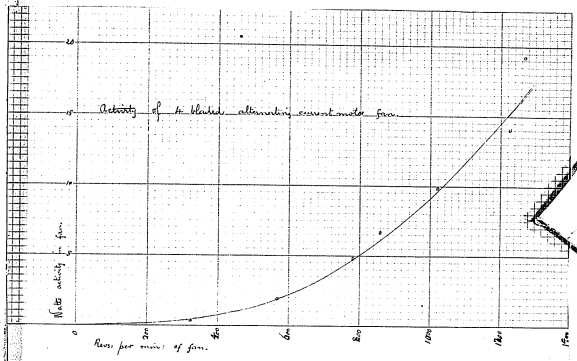
Interval of 43 secs. for examination — Slight reflex action.

2nd contact between head electrode on forehead and another electrode on calf of right leg 11. 13. 22 } 36 secs.
11. 13. 58

1500 volts 1 amp. steadily. 2.144 ω

No reflex action visible in any part of the body except the cremaster muscle in the examination made at 11.14.00

Energy accumulated for	E.M.F.	Run of motor	C	Power in farm units
17.5	28.3	2.4 revs per min	10.89	2.0
12.4	37.4		14.59	2.75
12.7	24.5	2.6 revs.	11.36	1.75
12.2	22.8		8.76	1.0
24.4	47.4		18.23	6.0
32.7	58.3		21.25	7.3



List of small Excelsior Alternating Fan Motor.

Jan. 26th.

The fan motor was coupled up with an ammeter, a voltmeter, and a dynamometer wattmeter so as to measure the currents and energy absorbed.

Speed in Motor at	Amperes in Motor circuit	Volts	Resistance in Wattmeter at	Torsion	α	R T	Energy in Motor watts	Speed of motor	Power in Swp. circ. watt	Net power in motor watts
77°	3.30	46	6210	54.5	1.42×10^{-10}	338,400	48.05	5.80	0.34	47.71
103°	3.82	44.3	"	60.5	-	376,700	53.35	6.51	0.32	53.03
86°	3.37	39.5	6100	51	-	311,100	44.17	5.49	0.26	43.91
62°	2.46	35.3	2140	127	-	271,800	38.59	4.54	0.58	38.01
129°	4.27	50.75	2180	255	-	555,900	78.94	8.55	1.18	77.76
157°	4.61	55	4160	162.5	-	676,000	95.99	9.26	0.73	95.26

Power absorbed in driving the fan at speed.

Motor in floating dynamometer and driving fan on an extended shaft.

N in of fan	R.P.S. of fan	Balance lb	Moment	6165 Moment	Activity watts	E.M.F. at fan motor terms	Current in fan motor	Activity in motor
324	5.4	50 gms	2.2	110	6.782×10^5	0.366	7.9	2.22	17.38
564	9.47		6.4	320	1.973×10^6	1.268	10.5	2.87	30.1
858	14.3		14.2	710	4.377	6.609	14.5	3.73	54.1
1020	17.0		18.5	925	5.703	9.695	17.0	4.18	71.1
1272	21.2		28.2	1410	8.692	18.43	22.	4.90	107.8
1224	20.4		22.2	1110	6.843	13.96	20.8	4.85	100.9
1020	17.0		18.7	935	5.764	9.80	18.8	4.52	85.0
780	13.0		11.7	585	3.607	4.689	15.5	3.93	60.9

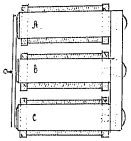
Cl. Dimens of field magnet circle = 12.15 area 116 sq. cms.

Length " " cylinder = 6.1

Volume = 707.6 c.c.

Deducting 6.1 × 1.5 × 4.35 = 39.8

667.8 c.c.



Reluctance of circuit $1/\left(\frac{0.636}{0.04}\right) + \left(\frac{0.636}{0.04} \times \frac{0.636}{0.006}\right)/\left(\frac{0.636}{0.04} + \frac{0.636}{0.006}\right)$

$$15.72 + \left(\frac{15.72 \times 9.43}{15.72 + 9.43}\right)$$

$$15.72 + \frac{148.3}{25.15}$$

$$15.72 + 5.90$$

$$21.62 \times 10^{-3}$$

When the current in the spool was 1.12 } representing a spool MMF of 716
the pull was 185 gms with C
226 " " D } showing effect of unequal air gaps.
253 " " A

With same current and pair of coils in series with the poles to armature
the pull was 510 gms with A + C
510 " " B + C
480 " " A + C

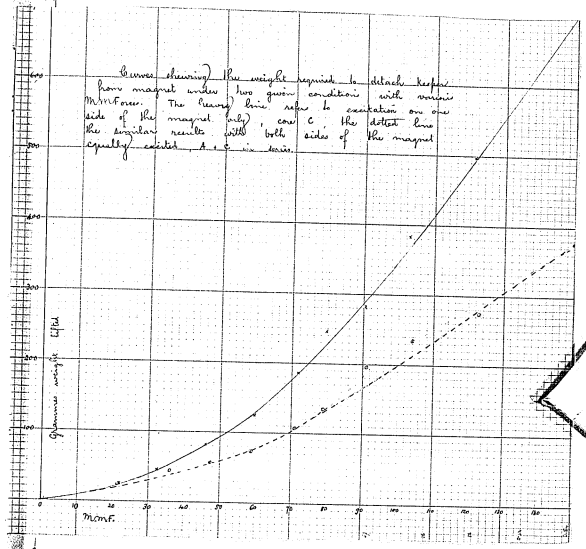
$$\frac{0.040}{0.636} = 15.72 \times 10^{-3}$$

$$\frac{0.006}{0.636} = 9.43 \quad "$$

$$25.15$$

$$12.59 \quad "$$

$$37.74$$



Measurement of Tractive force of a small Electromagnetic Relay. 16th Feby. 92

A triple coil magnet of the dimensions shown in section on the opposite page was mounted like a relay with an armature of soft iron horizontally pivoted before its poles. There were 50 turns of No 26 B.W.G. 0.033" silk covered to 0.038" in two layers of 25 turns on each coil making 150 turns on the whole apparatus. The resistance of each coil was 0.058 - or 18°C and its inductance with the armature after in the attracted position was 0.175 - 2.8 f - 0.403 h. The adjusting screw were set that the clearance at the pole A was 0.06, and at the poles B & C 0.01 with the armature attracted. The diameter of the polar faces were each about 0.9 making an area of 0.636 sq. in. The relay was mounted in a vertical position with the armature horizontal. By means of a hook and bracket the pull at the centre of the armature necessary to dislodge the latter against attractive force was observed under various conditions of exciting power.

1st Current through C only. other coils out of circuit.

Weight of pan	Weights on pan	Total weight lifted	Pull Dynes	Ohmic	Amp.	MMF	Calculated Flux	B calculated from Amps	B calculated from pull
23.81	1.38	25.2	2470	0.068	0.35	22.0	1018	801.6	1276
	22.2	46.0	4510	0.100	0.576	33.43	1500	1181	1720
	57.0	80.8	7930	0.142	0.733	46.07	2131	1678	2285
	100.5	124.3	12,200	0.184	0.950	59.70	2762	2175	2820
	161	184.8	18,130	0.221	1.140	71.64	3315	2611	3450
	221	244.8	25,100	0.245	1.265	79.50	3678	2897	4050
	257	282.8	27,750	0.278	1.435	90.20	4173	3287	4272
	355	381.8	37,460	0.318	1.642	103.2	4774	3760	4964
	475	498.8	48,940	0.375	1.936	121.7	5620	4434	5675
	680	703.8	69,040	0.462	2.384	149.8	6930	5457	6740

2nd Series Current through coils A + C in series like poles to armature

Weight of pan	Weights on pan	Total weight lifted	Pull Dynes	Ohmic	Amp.	MMF in each coil	Calculated Flux in each coil	B calculated in A from amps	B calculated from pull
23.81	0.50	23.8	2336	0.067	0.346	21.75	576	905	
	20.5	44.3	4,347	0.111	0.573	36.0	954	1500	
	32	55.8	5,476	0.145	0.748	47.0	1245	1957	
	49	72.8	7,144	0.181	0.934	58.7	1555	2445	
	84	107.8	10,580	0.219	1.130	71.0	1881	2957	
	110	133.8	13,130	0.244	1.259	79.1	2096	3295	
	172	195.8	19,210	0.281	1.450	91.1	2414	3795	
	210	233.8	22,940	0.321	1.657	104.2	2761	4341	
	250	273.8	26,870	0.379	1.956	122.9	3256	5118	
	350	373.8	36,680	0.462	2.385	149.9	3972	6244	

Edison = Lalande Batteries for operating the G.N.W. telegraph lines in Toronto Station

	Number	Name		Length	Total res.	Res. added	
220 cells EMF 154 volts Int. res. 11 ω Current 18 × 0.03 = 0.54 J Life time 600 hrs.	No 1	G.T.R.	East	333	19,000	–	1
	4	"	"	161	9500	500	2
	8	"	"	276	12,000	–	3
	11	"	"	360	11,100	–	4
	12		"	360	10,000	–	5
	14		"	272	9,350	650	6
	1	GTR	West	169	15,000	–	7
	3	"	"	120	9,100	900	8
	12	"	"	189	8,400	1600	9
	16	"	"	142	7575	2425	10
	35		"	200	8000	2000	11
	1		North	124	8270	1730	12
	3		"	237	12,800	–	13
	4		"	227	8000	2000	14
	5		"	171	8350	1650	15
	9		"	125	8000	2000	16
	14		"	193	9200	800	17
	1	CVR	"	125	8700	1300	18
150 cells. EMF 105 volts Int. res 7.5 ω Current 19 × 0.03 = 0.57 J Life time 600 hrs.	2	GTR.	East	*340	5850	1150	19
	$ 9		"	333	7000	–	20
	13		"	163	4590	2410	21
	15		"	333	6500	500	22
	23		"	333	6500	500	23
	2		West	175	6500	500	24
	$ 2	"	"	228	4700	2300	25
	6		"	196	6900	100	26
	9		"	100	6900	100	27
	14		"	100	5000	2000	28
	30		"	117	5130	1870	29
	34		"	142	6770	230	30
	39		"	257	7000	–	31
	15		North	75	4900	2100	32
	16		"	153	6470	530	33
	17		"	161	5740	1260	34
	21		"	227	7000	–	35
	2	CVR	"	87	6300	700	36
	Toronto	Bch		100	6100	900	37
75 cells EMF 52.5 volts Int. res. 3.8 ω. Current Life	10		West	120	3100	200	38
	15		"	120	3300	–	39
	31		"	120	3200	100	40
	33		"	40	1200	2100	41
	37		"	120	2800	500	42
	49		"	120	2330	970	43
	50		"	120	2300	1000	44
	1	City		10	1100	2200 ?	45
	2	"		15	2310	1090 ?	46
	4	"		15	2930	370 ?	47
	5	"		2	750	2580 ?	48
	Gold stock	"		2	700	2630 ?	49

Calibration of Alternating Current Ammeter for Sulbury

16th Feby. 92

This is a standard 12 ampère continuous current meter arranged for electrostatic purposes by inserting a vane moving in a sector box on the extremity of an aluminium arm. The instrument was inserted in circuit with the Gaumin dynamometer, and calibrated from 0 up to 9.5 ampères. The radius of the pointer extremity is 14.2.5 cms. and the chordal distances along this circle from the zero point are:– 0.5 – 0.175, 1 – 0.37, 2 – 0.9, 3 – 1.9, 4 – 3.05, 5 – 4.55, 6 – 6.25, 7 – 8, 8 – 9.75, 9 – 11.9.

The resistance of the instrument is 0.023 ω at 18°C.
" inductance " " " 0.069 mh. at no load 0.1014 mh. at full load

On the density of the luminiferous ether, by Thomson's method.

The energy in heat in the vicinity of the earth due to solar radiation is about 50 microergs per c.c. (on Thomson's data derived from Pouillet 39). If m be the ether mass per c.c. or density of ether. then mv^2 is a superior limit of the energy per c.c. assume $v = \frac{V}{n}$ where V is the velocity of transmission or 3×10^{10} then $\frac{mV^2}{n^2} = 50 \times 10^{-6}$ is our fundamental equation or

$$m = 50 \frac{n^2}{V^2} 10^{-6}$$

$$= \frac{50}{9 \times 10^{20}} n^2 . 10^{-6}$$

$$= 5.5 \times 10^{-26} \times n^2$$

Thompson assumes that n cannot be less than 50, whence

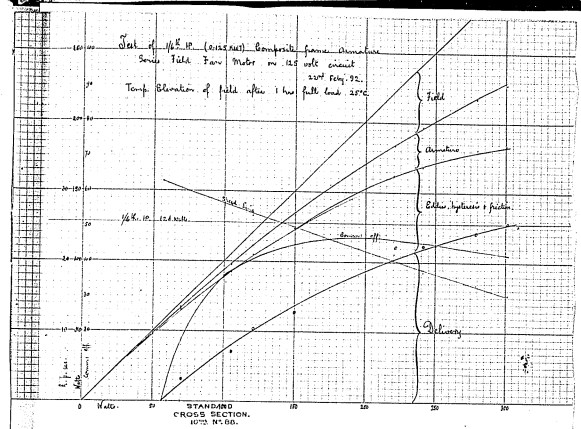
$$m = 1.38 \times 10^{-26} \times 10^{4}$$

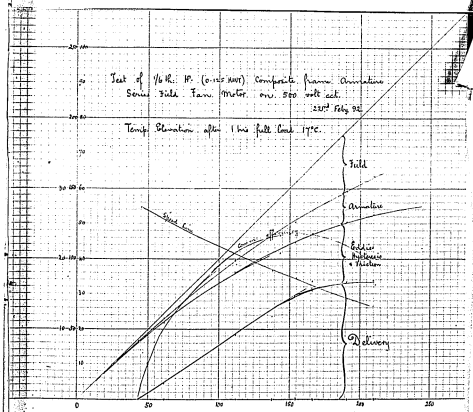
$$= 1.38 \times 10^{-22}$$

No. of Obs.	Time	Volts at motor terms.	Ohmch.	Amperes thro' motor	Drop in field	Res. of field	Energy in motor	Energy in field	Energy in armr.	Res. of armr.
1	13.20	125	0.187	0.552	5.5	10.0	69.	3.0	66.	6.5
2	.20	125	0.110	0.568	5.8	.2	71	3.3	67.7	6.5
3	.30	125	0.162	0.836	8.7	.4	104.5	7.3	97.2	6.6
4	.35	124	0.189	0.975	10.3	.6	121	10.0	111.0	6.6
5	.42	123	0.236	1.218	13.2	.8	149.8	16.1	133.7	6.7
6	.49	121	0.355	1.832	20.2	11.0	221.7	37.0	184.7	6.7
7	.55	120.5	0.389	2.007	22.5	.2	241.9	45.1	196.8	6.8
8	14.06	120.2	0.450	2.322	26.5	.4	279.	61.5	217.5	6.9
9	.15	119.	0.491	2.534	29.4	.6	301.6	74.5	227.1	6.9
10	15.05	121	0.496	2.560	30.2	11.8	310.	77.3	232.7	7.1
1	16.00	497	0.017	0.0877	24.3	277	43.6	2.1	41.5	149
2	.10	497	0.024	0.1238	34.5	279	61.5	4.3	57.2	150
3	.20	495	0.044	0.227	69.8	281	112.4	14.5	97.9	151
4	.25	495	0.054	0.2786	78.8	283	138.0	22.0	116.0	152
5	.30	495	0.060	0.3097	88.3	285	152.5	27.4	126.1	153
6	.32	497	0.065	0.3354	96.3	287	166.7	32.3	134.4	154
7	.36	500	0.074	0.3819	110.4	289	190.9	42.2	148.7	155
8	.45	497	0.082	0.4232	122.7	290	210.4	51.9	158.5	156
9	17.00	497	0.082	0.4232	120.4	308	210.4	55.8	156.2	161

Res. of 120 volt motor after test:— Field 11.8, Armr. 7.1 } Total 19.9 Temp. on field 112°F, air 68°F } Rise 44°F

120-volt motor driving c.c. large 6 bladed fan makes 1420 r.p.m. taking 0.55 p.d.w.





Tests of 1/6th H.P. Motors with wooden armatures 120 and 500 volts as finally prepared before delivery. 22nd July 92

Weight of 120 volt machine on wooden bases 26 lbs.
Extreme dimensions (not generally) occupied:
Res. of field @ 18° C 9.920 Armature 6.50 Total 16.42 ω.
Number of turns on armature 3592. all round 1.322" 1.322"
field 1378 0.028" 0.040"
Weight of 500 volt machine on wooden bases 25½ lbs. Same ext. dimensions.
Res. of field @ 18° C. 2770, Armature 149.4 ω Total 426.4 ω.
The two motors were coupled by a double Hooke joint with rod, the 120 volt motor being mounted in the floating cradle, and the 500 volt motor outside.

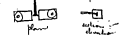
Load in lbs.		Speed rpm	rps	E.M.F. of armt.	E.M.F. per turn per sec.	Effiel	Current	Moment	Output	Friction	Dynamo eff.
1.5	1.5	1878	31.3	116.	3.705	64.2	50 @ 1.0	–	–	64.2	–
3.7	2.1	1950	32.5	115.5	3.55	65.6	50 @ 1.6	800	16.0	49.6	0.225
5.5	4.6	1685	28.1	110.8	3.94	92.6	50 @ 4.1	2050	35.5	57.1	0.319
6.4	6.2	1593	26.6	107.3	4.03	104.8	50 @ 2.3 / 100 @ 1.0	3150	51.7	53.1	0.427
8.2	10.0	1489	24.8	101.6	4.10	123.7	50 @ 2.3 / 200 @ 1.5	4165	63.7	60.0	0.425
9.3	22.5	1265	21.1	88.5	4.20	162.2	50 @ 4.5 / 300 @ 1.5	7475	110.3	52.	0.498
9.7	27.4	1113	18.6	84.3	4.53	168.4	50 @ 5 / 500 @ 1.5 / 100 @ 1.0	9650	110.7	57.7	0.458
9.8	36.7	1008	16.8	77.9	4.64	180.8	50 @ 6 / 100 @ 1.5 / 500 @ 1.0	11,700	121.2	79.5	0.434
9.5	44.3	909	15.2	72.1	4.74	189.8	50 @ 7.5 / 200 @ 1.5 / 500 @ 1.0	13,650	127.9	88.7	0.422
9.2	46.6	909	15.2	72.6	4.78	186.8	50 @ 8 / 300 @ 1.5 / 500 @ 1.0	14,050	122.3	92.2	0.395
2.0	1.1	1630	27.16	459.7	16.93	40.4	50 @ 0	–	–	40.4	–
4.0	2.3	1593	26.6	443.9	16.69	54.9	50 @ 0.5	475	11.87	43.8	0.181
6.3	7.8	1146	19.45	396.9	20.72	90.1	50 @ 2.5 / 100 @ 0.5	3850	45.55	44.6	0.405
8.4	11.8	1093	18.2	373.8	20.54	104.2	50 @ 4.2 / 200 @ 0.7 / 100 @ 0.5	5250	58.9	45.3	0.427
9.4	14.7	1027	17.1	359.3	21.0	111.4	50 @ 5.5 / 200 @ 0.7	7000	73.8	37.6	0.481
9.6	17.3	922	15.4	349.1	22.7	117.1	50 @ 7 / 300 @ 0.5	8350	79.3	37.8	0.476
9.2	22.6	850	14.2	330.4	23.27	126.1	50 @ 9.5 / 300 @ 0.5	9500	83.2	42.9	0.436
9.0	27.9	784	13.1	308.3	23.53	130.6	50 @ 12.5 / 300 @ 0.5	10,375	83.8	46.8	0.399
8.1	28.8	784	13.1	298.5	22.79	126.4	500 @ 0.6	10,000	80.8	45.6	0.384

Res. of 500 volt motor after tests: Field 308 ω, Armt. 161 ω } 469. Temp. on field 95°F, air 65°F } Rise 30°F.

500 motor driving C.C. large 6 bladed fan makes 1170 rpm. & takes 0.2067. 103 ω

1st Owing to the rotation of the plane of polarisation of light along the lines of stress flux, it has been supposed that the magnetic activity of air or vacuum consists in a twist or rotation, either as a static vortex or a dynamic whirl. Maxwell's vortex theory is based on this supposition. To test this theory the following experiments were made:—

A plane mirror, a circular disk of silvered glass about 1 cm in diam, was fastened with beeswax to a paper tube and by this supported in a vertical plane between the poles of the large electromagnet (see page



) so that the normal to the mirror was parallel to the pole faces, and the centre of the mirror was in the centre of symmetry of the field. There was about 0·1 clearance between edge of mirror and pole, the latter being about 1·2 apart. The magnet was excited direct from 120 volt mains. By the use of the spectometer telescope, a fiducial mark distant 20 metres from the mirror had its image examined by a Ramsden eyepiece at 20 metres

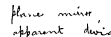
The image was marked by the cross wire and excursions looked for when the current in the magnet had its direction reversed. Had an excursion of image representing 0·05 at 2000 taken place it would certainly have been observed, and if it had been only 0·02 in 2000 it would probably have been detected. No such disturbance was noticeable.

2nd A concave mirror of about 1 metre focus was substituted for the plane mirror to avoid the influence of extended surface in diminishing apparent deviation. No better success.

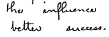
3rd The concave mirror was immersed in a glass chamber containing CS_2 so that the rays had to pass in entering and emerging through some 5 cm of the liquid. Still no deviation.

4th A beam of light passing across the field through the CS_2 with mirror removed, showed no deviation.

5th A small glass prism (equilateral) was suspended between the poles



also



and the D lines watched in telescope when current applied and reversed. Nothing observed.

6th A plate of glass 10·2 × 8·2 × 0·1 was coated on one side with a film of gold by M. Wolfly. The plate was covered with this coat fairly uniformly over an area 10·2 × 6. The plate was quite translucent, its color being a bluish green, but by transmitted light. Contact at two opposite points 8·5 apart

was made by a drop of mercury at each and the brass circle of each drop was about 0·7 in diam. Copper wire dipped into the mercury. The plate was held horizontal coated side up, midway between the poles of the magnet separated by 0·85. The res. between electrodes under these conditions was approximately 8.000Ω. If this represents 8·0 × 5 cm, of pure gold, the thickness of the film is 4×10^{-6}. Thomson's estimate of the diameter of a molecule is 10^{-7}, so that it is quite likely that bad contact round the edge of the mercury or partial discontinuities in the film may have made the resistance much greater than that fairly due to its thickness. No change could be detected in the resistance when the magnet was excited. The resistance was never quite steady but it is certain that a change of 3% could have been detected.

7th The film was then mounted on leaden strips supported by a second glass plate, and the two clamped together. The resistance between lead strips was about 23,000Ω. This was inserted between the lid and the central core of the 2 KWT transformer which was then voided to 1100 volts. 160 ~. No visible change in resistance took place although the flux actually reversed across the film. 10Ω could have been observed in the 23000Ω measured. No better success with the plate parallel to transformer core.

$$\frac{8 \times 2 \cdot 2 \times 10^{3}}{5 \times 10} = 3 \cdot 0 \times 10^{-4} \times 10^{3}$$

$$\frac{17 \cdot 6 \times 10^{3}}{5 \times 10} = 3 \cdot 0 \times 10^{-3}$$

$$\frac{3 \cdot 53}{2} = 3 \cdot 0 \times 10^{-4}$$

$$z = 1 \cdot 173 \times 10^{-10}$$

Cross section of nickel in ring #1 = 3.955 sq: cms

$$\phi = \frac{1.41 \; E \times 10^8}{N \; p} = \frac{1.41 \times 10^8 \; E}{70 \times 10^4 \times 1.19 \times 10^4} = \frac{1.41 \times 10^4}{62.3} E = 2.27 \times 10^2 E =$$

$$= 227 E$$

On the Resistance and Capacity of Telegraph wire in a cable from Jersey City to Elizabeth N.J.

It is proposed to employ # 14 B.&S. 0.064.1" diam: having 4109 c.mils and 13.27 ω per mile @ 20°C. for conductors. allowing 0.0625" (1/16") for thickness of insulation, this gives 0.1891 for the whole wire ∴ D/d = 2.95 log. D/d = 1.082. 2.46 = 0.4622 × 0.1788 = 0.0826 × 3 = 0.248 ℔ per mile.

If # 10 B.&S. wire were used, (0.1019" diam having 10,384 c. mils and 5.25 ω per mile @ 20°C. the capacity would be somewhat increased.

Measurements of Hysteresis in Nickel as detailed on the following page.

The two rings of nickel wire already tested see pp 20 and 29 were measured again. The results are plotted in the two black curves. The upper one accords with the law $H = \alpha B^{\frac{4}{3}}$, but the lower one does not. This agrees with the previous tests. On examination, the second ring was unwound. It was discovered that the bare nickel wire beneath was parcelled with a few turns and this might readily induce currents and absorb energy. The parcelling turns were taken out and the ring rewound with 605 turns of the same wire. The third series and the ~~upper~~ red line indicate the results which now accord with the $H = \alpha B^{\frac{4}{3}}$ law.

Particulars of 1.5 200 KWT generator at work in the 26th Street Station 12th Mar: 92.

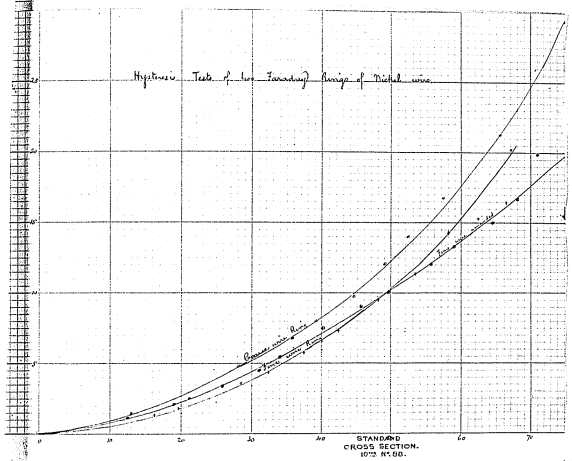
Outside diameter of body	83.5"
Inside . . .	75.5"
Length of body over disks	17.25"
Armature winding	1008 bars
Cross section per bar	235 × 305 mils
Field winding 169 lbs. of # 15 B+S. per core	
Turns per core	4460
Resistance per core	54.44 ohms.

Cores to be connected in parallel

Res: bar to have a total resistance of 6 ω

and a maximum current capacity of 31 amperes.

No. of Obs.	Deflection	α	R.	Watts in coil	c	c²	c²/R watts per cent.	γ	μ or r
1	35°	2·365×10⁻⁶	2007	1·567	13	169	0·0811	–	3·12
2	69.5°		"	3·30	21·4	458	0·228	0·1?	
3	110·5°		"	5·226	28·6	818	0·4108	0·15?	
4	163·5°		"	7·761	36·8	1354	0·675	0·3	
5	192		"	9·116	40·2	1616	0·805	0·33	
6	237·5		"	11·28	45·7	2088	1·040	0·39	3·36
7	294		"	13·96	50·3	2530	1·261	0·42	3·20
8	163°		4012	15·47	53·8	2894	0·721	0·47	3·26
9	148·5		"	18·84	59·2	3505	0·873	0·57	3·36
10	266		"	25·24	68·7	4720	1·176	0·92	3·36
11	293·5		6081	49·20	81·5	6642	1·090	1·85	3·36
12									
1	32·5°		2007	1·543	17·6	310	0·155	–	
2	43·5		"	2·065	21·5	462	0·230	–	
3	56·5		"	4·107	32·1	1030	0·513	0.1?	
4	108·		"	5·127	36·7	1347	0·671	0.15?	
5	142		"	6·740	43·	1849	0·921	0.2?	
6	183		"	8·688	49·5	2450	1·221	0.25?	
7	240		"	11·395	57·5	3306	1·647	0·35	2·0620
8	294·5		"	13·98	64·5	4160	2·073	0·54	"
9	180		4012	17·08	72·2	5213	1·390	0·86	"
10	202·5		"	19·22	77·6	6022	1·50	1·10	"
11	229·5		"	22·73	82·6	6823	1·70	1·50	"
12	318·		"	30·17	87·5	7656	1·908	1·96	2·0620
1	25·5	2·365×10⁻⁶	2007	1·21	12·5	156.	0·077	–	1·844
2	48			2·28	19	361	0·180	–	1·82
3	77·5			3·68	25·9	671	0·334	–	1·83
4	108			4·98	31	961	0·479	0·1	1·84
5	128			6·08	34	1156	0·576	0·15	1·85
6	84		4012	7·97	40·25	1620	0·404	0·2	1·86
7	102·5			9·724	45·7	2088	0·521	0·3	1·87
8	116			11·01	49·75	2480	0·618	0·36	1·88
9	140			13·28	56	3136	0·782	0·49	1·89
10	157			14·90	59·5	3540	0·882	0·62	1·90
11	186			17·65	66	4356	1·086	0·9	1·91
12	216·5			20·54	70·5	4970	1·239	1·21	1·92
13	234			22·21	76·5	5700	1·421	1·64	1·93
14	296·5			28·13	78·	6084	1·517	1·97	1·9935



Measurements of Hysteresis in Nickel

May 15

A bar of nickel since Faraday (Ring already referred to on pp. 20 + 29 were employed as before. The corrections were those on page 20.

γI	$I^2 r$ watts	$\gamma I + \frac{c^2}{R}$	Watts in nickel.	Rise in temperature	Ra	φ	B	e.c.	Erg per c.c. per sec.
-		0.084	1.483	13	4.747×10^{-2}	2950	746	253.1	41.37
0.312	0.031	0.289	5.841	21.1	-	4790	1210	$\times 14.6$	84.84
0.468	0.072	0.478	4.768	28.1	-	6377	1612	$= 3.553 \times 10^{5}$	133.1
0.936	0.308	0.956	6.805	35.9	-	8148	2060		189.9
1.03	0.340	1.145	7.971	39.2	-	8896	2250		222.5
1.20	0.456	1.496	9.78	44.5	-	10,100	2554	9.43×10^{-6}	273.
1.344	0.564	1.825	12.135	49.0	-	11,120	2812		338.6
1.532	0.720	1.441	14.03	52.3	9.488×10^{-2}	11,870	3000	$\times 9.43 \times 10^{-6}$	391.5
1.983	1.17	2.040	16.80	57.2	-	12,980	3280		468.7
3.09	2.84	4.016	21.22	65.6	-	14,890	3765		592.1
6.21	11.149	12.58	29.63	75.3	14.38 -	17,090	4320		826.4
-	-	0.155	1.388	16.2	4.747×10^{-2}				
-	-	0.230	1.835	19.7	-				
0.206	0.021	0.534	3.573	28.6	-				
0.309	0.046	0.717	4.410	32.3	-				
0.412	0.082	0.903	5.737	37.3	-				
0.516	0.129	1.350	7.338	42.2	-				
0.722	0.253	1.900	9.495	48.0	-				
1.114	0.602	2.675	11.305	53.2	-				
1.774	1.526	2.826	14.254	58.0	-				
2.248	2.495	3.995	15.225	62.4	9.488×10^{-2}				
3.093	4.640	6.340	16.39	66.2	-				
4.062	7.924	9.832	20.34	67.2	-				
-		0.08	1.13	12.5	4.747×10^{-2}	3284	828.6	$\times 3.553 \times 10^{5}$	34.88
-		0.18	2.10	19		4991	3764	6.54×10^{-6}	58.60
-		0.33	3.35	25.9		6804	1717	6.54×10^{-6}	93.56
0.18	0.02	0.50	4.48	31.		8144	2055	6.26×10^{-6}	135.1
0.28	0.04	0.62	5.46	34	9.488×10^{-2}	8932	2253	6.55×10^{-6}	152.4
0.37	0.07	0.47	7.50	40.15		10,560	2664		204.4
0.56	0.17	0.69	9.03	45.53		11,960	3017	6.83×10^{-6}	252.6
0.68	0.25	0.87	10.14	49.5		13,010	3282	6.70×10^{-6}	283.0
0.94	0.46	1.24	12.04	55.54		14,590	3681	6.62	336.0
1.19	0.71	1.59	13.31	58.79		15,450	3897	Sings.	377.6
1.70	1.53	2.62	15.03	64.47		16,940	4273		419.5
2.30	2.57	3.81	16.73	68.0		17,970	4528		466.9
3.17	5.20	6.62	18.59	70.3		18,470	4660		538.1
3.62	6.77	8.29	19.84	71.23		18,710	4720		583.7

Results of measurements made by Mr A. O. Tate of the current strength on all the telegraph wires entering the Toronto Office of the great Northern Telegraph Co: Mar. 92.

Sixty one measurements were made by Mr Tate of the working current on as many different circuits, taking a milliampere meter and inserting it at the switchboard. The sum of the 61 readings was 1.215 amp. representing an average of 0.020 amp. to each circuit. These are all worked on the closed circuit plan, a few are worked duplex. They vary in length from 333 to 1 mile and a fair proportion are batteried at other stations in circuit. The maximum measured current was 0.10 (not included in the average) for a City Gold stock circuit. Next to that was one line taking 0.045. The minimum was 0.012 observed in one case and next to that 0.018 in several cases. 0.020 is a fair average for all lengths in ordinary weather. Forty nine circuits were operated from 12 Bullard batteries varying from 90 to 132 cells each. The maximum calculated p.d. at battery terminals being 128 volts and the minimum 58 v. The total number of cells in use was 1117 averaging 100 cells each (besides one Edison Lalande battery of 2 cells that works 16 other circuits). The cost of these Bullard cells is from 48 ¢ to 53 ¢ per cell per annum in material. At 50 c = $600. There is thus an average of 4 circuits to the battery or 25 cells to the circuit. The maximum current supplied from any one battery was 0.110 ⓐ.

Estimates on Electric Lighting Work.

Costs of laying in Cities obtained from Mr Lundt 21st Mar.:

Laying + Testing	Mains	18 ¢	per running foot
. . .	Feeders	23 .	. . .
Trenching + filling either		50 .	. . . . of each.

In houses, the average number of lamp outlets is rather more than 1/3rd of the number of lamps, or nearly 3 lamps per outlet. The cost of labor for wiring is commonly 2 ¢ per running foot for moulded work.

Estimated List Price of ⅌400 KW. dynamos obtained from Schenectady 21. 3. 92.

List Price	$ 37,000 each
Annunciator -	100
Volt indicator -	75
	$ 37,175

Weight of dynamos + engines in multipolar

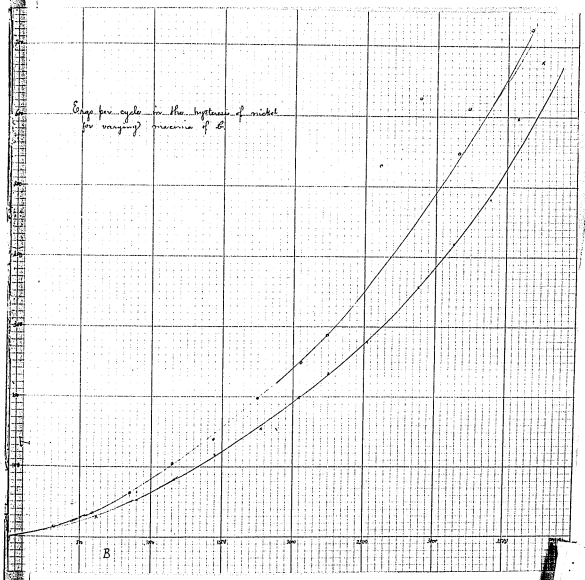
100 KW. dyn:	25,000 lbs. each
200 - -	44,000 - - -
400 - -	75,000 - - -
2 X 100 KW Engine	75,000 lbs.
2 X 200 . -	175,000 .
2 X 400 . -	360,000 -

Costs of operating dynamos only in Central Stations.

Case 1.	40	⅌ 60	KW.	= 2400	KW	1	Off dynamo	now	5	accts.	168	hrs. per week	$91	=	3.38	per 100 KW
Mon	Tue															
" 2	24	⅌ 60	KW	= 1440	"	1	- -	-	4	-	168	- - -	$60	=	4.17	- - -
" 3	14	⅌ 100	-	= 1400	"	1	- -	-	2	-	-	- - -	$45	=	3.21	- - -
" 4	12	⅌ 100	.	= 1200	"	1	- -	-	2	-	-	- - -	$42	=	3.50	- - -
" 5	8	⅌ 100	-	= 800	"	1	- -	-	1	-	-	- - -	$ 36.75	=	4.60	- - -
" 6	20	⅌ 60		= 1200	"	1	- -	-	4	-	-	- - -	$ 106	=	8.83	- - -

Ring #1 570 turns of nickel wire #19 B.&S. varying by 0.0365" or 0.0927 in turns.
Section of wire 6.7149×10^{-3} sq in
Mass of wire 2255 grms. Boiled in melted paraffin wax
Volume " 253.0 c.c.
Int. diam 52.5 cent. 79. Mean 65.75
Mean cross section of ring 3.952. by cent. diameter
" " " 3.848 " number of wires
Wound by 700 turns of #22 B.&S. wire Lapse.

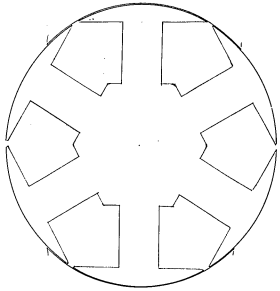
Meas. No.	Degrees θ_1	α	R	Rc	R.c.r. Volts in cent.	e	e'	e'/R	γ	
1	24°	2.365×10^{-5}	1007	2.381×10^{-5}	0.571	5.5	30.25	0.030	–	3.45"
2	57		"	"	1.357	10	100	0.099	–	"
3	105.5		"	"	2.512	14.5	207.4	0.206	–	"
4	84		2007	4.746	3.987	20	400	0.199	0.15	"
5	115		"	"	5.457	25	625	0.312	0.2	"
6	107		3007	7.112	7.61	30.5	930.3	0.309	0.25	"
7	135.5		"	"	9.036	35.8	1281.6	0.426	0.3	"
8	158		"	"	11.24	38.9	1513.2	0.503	0.36	"
9	211		4007	9.476	20.0	45.5	2070.	0.517	0.44	"
10	253		"	"	23.98	50.5	2550.	0.636	0.55	"
11	234		"	"	22.18	56.0	3136	0.783	0.75	3.10
12	271		"	"	25.69	61.4	3770	0.941	0.95	3.12
13	284.5		5800	1.230×10^{-2}	31.3	66.	4436	0.853	1.20	3.14
14	310		"	"	36.12	71.3	5084	0.978	1.60	3.18
15	135		3007	7.112×10^{-5}	9.60	35.5	1260	0.419	0.30	3.15
1	23.5		1007	2.381×10^{-5}	0.557	5.5	30.25	0.030	–	2.315
2	49.5		"	"	1.179	10.5	110.25	0.1095	–	"
3	88		"	"	2.096	15.2	231.0	0.229	–	"
4	66.5		2007	4.746	3.156	20.	400	0.199	0.1	"
5	98		"	"	4.652	25.7	660.5	0.329	0.15	"
6	84		3007	7.112	5.975	30.5	930.3	0.309	0.2	"
7	110		"	"	7.822	35.4	1253.2	0.417	0.3	"
8	129		"	"	9.174	39.1	1529	0.509	0.33	"
9	115		4007	9.476	10.9	43.8	1918	0.479	0.38	"
10	152.5		"	"	14.45	50.5	2550	0.636	0.60	"
11	183		"	"	17.34	55.4	3069	0.766	0.82	"
12	234		"	"	22.18	60.8	3697	0.923	1.18	2.85
13	239		5800	1.23×10^{-2}	29.4	65.0	4225	0.812	1.58	2.57
14	290		"	"	35.67	69	4761	0.915	1.90	2.29
15	110		3007	7.112×10^{-5}	7.822	35.5	1260	0.419	0.3	"



Hysteresis measurements with Nickel contd. Nov. 18th

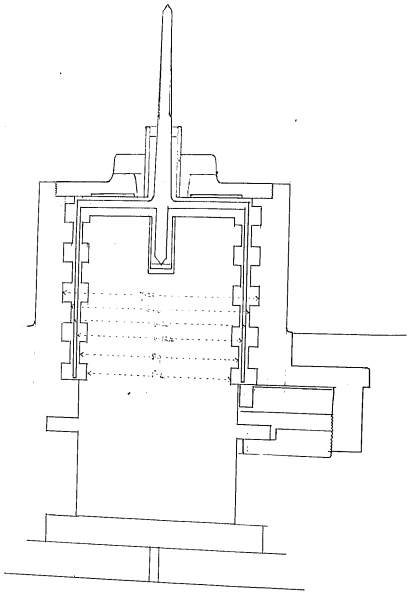
Ring # 2. 4160 turns of nickel wire # 28 B&S 0.0126" (0.032)
Volume of wire 8.014 X 10⁻⁶ cu. in.
Mass of wire 2255 grms. Soaked in melted paraffin wax
Volume " " 253.3 c.c.
Sat. wax: 53.5 Ord: 78. Means 65.75
Mean cross section of ring 3.852 by dimensions of ring
3.345 " measured of turns & size of wire.
Winding 700 turns of # 22 B&S cow tape.

I	J^r	$J^r + c/k$	Watts in Nickel.	ft. lb. diss. in Nickel.	φ 227 (μ)	B $\varphi/3.85$	$ni \times n$ 253.3/4160	Energy in ft. lb.	η
	-	-	0.03	0.54	5.5	1249	324.4	3.586×10⁻⁶	15.06	-
	-	-	0.10	1.26	10	2271	590		25.83	-
	-	-	0.21	2.30	14.5	3295	855.8		64.13	0.0013014
0.45	0.07	0.27	3.72	19.55	44440	1153			103.7	-
0.61	0.12	0.43	5.03	24.39	5339	1439			140.3	-
0.76	0.19	0.50	7.11	29.74	6754	1754			198.3	-
0.92	0.28	0.71	8.93	34.88	7922	2058	Coarser wire ring		249.0	0.0012143
1.10	0.40	0.90	19.34	37.80	8584	2230			288.3	0.0012166
1.34	0.57	1.01	18.99	44.16	10,030	2605			529.5	-
1.68	0.92	1.56	22.42	48.82	11,090	2880			625.1	-
2.33	1.75	2.53	19.65	53.67	12,190	3166			547.9	-
2.96	2.81	3.75	21.94	58.44	13,270	3446			611.8	-
3.77	4.53	5.38	25.92	62.23	14,140	3673			722.6	-
5.09	8.14	9.12	29.0	66.21	15,040	3907			808.5	-
0.95	0.29	0.71	8.89	34.55	7,846	2039			247.9	-
	-	-	0.03	0.54	5.5	1249	324.4		15.06	-
	-	-	0.11	1.07	10.5	2,384	619.2		29.83	-
	-	-	0.23	1.87	15.2	3,452	896.5		52.13	-
0.28	0.03	0.23	2.93	29.72	4,479	1164			81.68	0.0016015
0.42	0.06	0.39	4.26	25.28	5,741	1491			118.8	-
0.56	0.12	0.42	5.56	29.94	6,800	1766			155.1	-
0.84	0.25	0.67	7.15	34.56	7,848	2039	Fine wire ring		199.4	-
1.03	0.31	0.73	8.35	38.97	8,668	2252			232.8	0.0011011
1.08	0.42	0.90	10.0	42.72	9,702	2520			278.8	-
1.68	1.01	1.65	12.8	48.82	11,090	2881			356.9	-
2.33	1.91	2.68	14.66	53.07	12,050	3130			408.7	-
2.96	3.96	4.89	17.30	57.44	13,050	3390			482.4	-
4.54	7.17	7.98	21.42	60.46	13,730	3566			597.2	-
7.49	10.43	11.35	24.32	62.51	14,430	3748			678.2	-
0.54	0.26	0.68	7.14	34.63	7,864	2043			199.1	-



Design for a Battery Fan Motor of simple and cheap construction.

Power	=	5 watts
Speed	=	900 r.p.m.
Battery employed	=	4 cells of Edison-Lalande Battery 300-amp-hr type.
EMF	=	2·8 volts.
Current	=	4 amps
Res. of battery	=	4 × 0·05 ω = 0·2 ω
Drop in battery	=	0·8 volt
P.D. at battery terms.	=	2·0 "
P.D. at motor terminals	=	1·9 "
EMF of motor	=	1·3 "
Flux	=	20,000
Number of wires	=	120 or 70 in each limb
Armature type	=	Bipolar limbed.
Cross. section of limb	=	1·5" × 1·5 = 2·25
Effective	=	2·0 sq. cms.
Polar surface	=	5" × 1·5" = 7·5 cms²
Entrefer	=	0·020" = 0·05 cms
Air reluctance	=	0·1/7·5 = 0·0133
MMF needed	=	266
A.T.	=	213
Turns at load	=	53
Core of field magnet	=	Cast iron
Intensity in core	=	6000
Leakage factor	=	1·4
Total armature flux	=	30,000 at successive intervals
" field	=	42,000
" " section	=	8·4 sq. cms
Diameter of field	=	3·3 cms. = 1·33".
Length of mean armature		0·25"
" " winding	=	10·6"
Res. of motor allowed	=	0·15 ω
" " armature	=	0·08 ω
" " armature wire	=	0·32 ω
Feet per ohm	=	3·30'
Size of wire	=	~~#17 B.W.G. 0·058" d.c.c. 0·065"~~
Inter-layer insul.	=	0·85" = 12 turns.
Diameter of field	=	1·33"
Core "	=	1·19" = 0·35'
Length of wire	=	20·0'
Res. "	=	0·07 ω
Wire	=	0·00035 ω per foot #17 B.W.G. 0·058" p.c.c. to 0·065".
Weight	=	0·2 lbs.



Tests and Particulars of new Edison Model Dial Recording Meters.

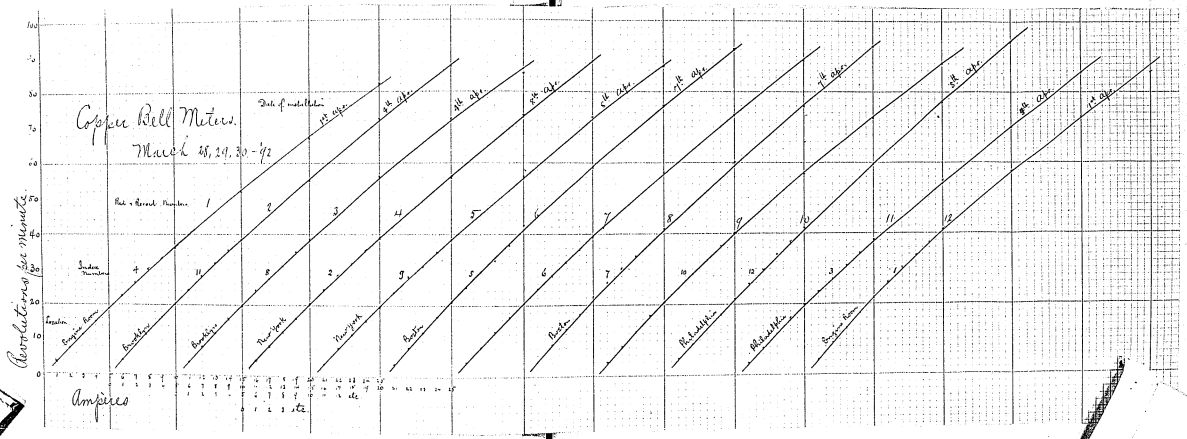
Further models were prepared similar to that whose tests and developments have been recorded.

8 meters were sent out

2	to	Newyork on the 30th March, installed on the 8th Apr.	
2	"	Brooklyn	4th "
2	"	Philadelphia	5th "
2	"	Boston	7th "

of these one sent to Boston did not work properly and was sent back after installation.

#s 9 & 11 were set up on 20 lamps steady load 16 hrs daily on the 9th Apr with amalgamated shafts indexes at zero.
At 12·30 on the 16th April, the readings were #9 16,647 #11 16,854.


Copper Bell Meters.
March 28, 29, 30 - 92
Date of installation
1st obs.
2d obs.
3d obs.
4th obs.
5th obs.
6th obs.
7th obs.
8th obs.
9th obs.
10th obs.
11th obs.
12th obs.
Meter Record Number
Index Number
Position
Engine Room
Brooklyn
Brooklyn
New York
New York
Boston
Boston
Philadelphia
Philadelphia
Engine Room
Accumulations in minutes
Amperes

The assays of these samples by Gideon E. Moore show

antimony	2	1. 1.775
	15	2. 0.011
	1	3. 0.145
	26	4. 2.016
	31	5. 1.880
	0	6. 0
	3	7. 1.721

Facts ascertained in connection with electric lighting for Chicago and the World's Fair.

The cost of wiring from services to lamp in the World's Fair Buildings including switches, cut-outs, mains, risers, tap lines, sockets (keyless) and lamps is $ 2.00 per lamp.
The cost of dynamos of large capacity is $ 3.38 per lamp at list and $ 2.17 at customer's rates, $1.33 at licencees rates.
Insurance for World's Fair reckoned at 1.5 % for 18 months
Cost of coal in Adams St. Station is $3.25 delivered per ton
" " " prospected " $2.00 "
Load in Adams St. station reached 15,000 ampères one day last winter
The previous winter it reached about 12,000 and it is contemplated to reach 20,000 in the coming winter.
The average cost of wiring to the local company is $3.00 per lamp installed in ordinary houses.
About $ 100 would be the average cost of wiring a house.
The average return from a house is $70 annually.
8 $ 600 (150 KWTs) and 20 $ 325 (100 KWTs) are installed.
The 100 KWT machines are not operated above 500 ampères and the 150 KWT " " " " 1000 "
Rate are 1¢ per lamp hour. 16 cp.

Test of a new plate-holder in the Edison-Lalande cell.

A 100 amp-hr cell was set up on the 25th March in the usual manner except that copper straps were screwed out to the zinc plate below the surface of the solution, and no oil was used. The weight of each plate was 252½ gms. including holder. This weight remained unaltered up to the 9th Apr., and no appreciable local action appeared to have taken place although the junction was underneath the liquid. A film of zinc appeared to be deposited on the copper, up to the level of the surfaces.
The cell was kept at work on 3 ampères during several days. Curves of its behavior were obtained.

Tests of lead in telephone cables sheathing

Seven samples of lead were received for examination and trial from New York

# 1	is pure Edison cold-press lead with admixture of 2.0 % tin	
# 2	" " " " " " with admixture of 1.5 % tin	340 ohm
# 3	" " " " " " " "	1.0 "
# 4	" " " " " " " "	2.6 "
# 5	" " " " " " " "	3.1 " 360 ohm 9th in 24 hrs
# 6	" " " " " " " "	0
# 7	" Western Electric hot press-lead " " " "	

These samples were sent to Gideon E. Moore 221 Pearl St. N.Y. for analysis on the 13th Apr.

Measurement of Constants of Dynamometer (Differential Type).

The following tests were taken of the Aporrow differential dynamometer constants.

No. of Obs.	Coil	Res. @ 20°C	Ind. M.Henry	C. Amperes	c.	Cc	τ	α	Mean α	v	
1	Upper #1 6 turns	0.02234	0.0225 L	10.568	0.01581	0.16708	136°	1.227×10^{-2}		+0.023	
2				13.358	0.01599	0.21359	169.2°	1.261 "		-0.010	1.2716 0.0112 $\times 10^{-3}$
3				13.288	0.0295	0.37662	308°	1.222 -		+0.029	
4				3.426	0.02966	0.10160	78.5°	1.294 -	1.257×10^{-2}	-0.043	
5	Upper #2 28 turns	0.03884	0.05835	1.803	0.01636	0.029497	12°	2.379×10^{-2}		-0.021 / -0.004	
6				0.940	0.03327	0.031274	126.5°	2.472 -		+0.069	2.3833 0.040 $\times 10^{-4}$
7				2.280	0.03299	0.07522	327°	2.300 -		-0.033	
8				2.295	0.03312	0.076011	319.2°	2.381 -	2.383×10^{-2}	-0.002 / -0.078	
9	Upper #3 120 turns	0.9344	0.588	0.9005	0.01624	0.014624	285.5°	5.122×10^{-2}		+0.012	
10				0.4523	0.01620	0.007327	141.8°	5.132 -		+0.002	5.134×10^{-2} ± 0.0026 $\times 10^{-2}$
11				0.4502	0.02050	0.01323	255°	5.148 -	5.134×10^{-2}	-0.014 / +0.0262	
12	Upper #4 432 turns	7.111	5.440	0.2007	0.016443	0.003297	222.8°	1.304×10^{-2}		-0.003	
13				0.1153	0.016114	0.001869	114.4°	1.292 -		-0.001	1.291 0.0013 $\times 10^{-2}$
14				0.1994	0.02010	0.006009	313.5°	1.278 -	1.291×10^{-2}	+0.012 / 0.027	
15	Lower #1 2 turns	–	–	18.79	0.01991	0.37411	87°	4.300×10^{-2}		-0.001	
16				18.726	0.02893	0.54172	126.5°	4.282 -		+0.017	4.299×10^{-2} ± 0.0066 $\times 10^{-2}$
17				18.579	0.03901	0.72477	168°	4.314 -	4.299×10^{-2}	-0.015 / +0.031	
18	Lower #2 12 turns	–	–	11.542	0.01627	0.18894	92°	2.054×10^{-2}		0.007	
19				11.627	0.03223	0.39800	192°	2.073 -		0.012	2.061 0.0081 $\times 10^{-2}$
20				18.503	0.03113	0.63151	307°	2.057 -	2.061×10^{-2}	0.004 / 0.023	
21	Lower #3 28 turns	0.0218	0.05265	3.225	0.01632	0.052632	198.5°	2.602×10^{-2}		0.002	
22				1.925	0.01645	0.031666	120°	2.639 -		0.011	2.630 0.0081 $\times 10^{-2}$
23				2.380	0.03429	0.081611	307°	2.658 -	2.630×10^{-2}	0.007 / 0.041	
24	Lower #4 120 turns	0.3598	0.3893	0.4374	0.01617	0.007077	128°	5.526×10^{-2}		0.009	
25				0.909	0.01617	0.014698	265.5°	5.536 -		0.001	5.535 0.0 $\times 10^{-2}$
26				0.5497	0.0297	0.017811	321.5°	5.543 -	5.535×10^{-2}	0.008 / 0.018	

Suspended coil #3 0.75 int. Bolts 2.8 ext. diam., 3.2 diam. 0.096 (probably) 27 degrees of 25 turns
0.008" width 0.010. 1361.0

Upper suspension

19.50	6.94 L	0.352 $\frac{19.52}{\text{Torsion}}$		

Weight of each coil 30 grms approx.
- - whole susp system about 65 grms

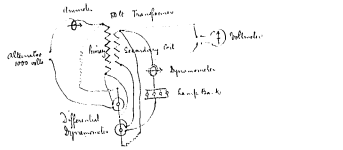
Lower suspension

17.75	6.41 L	0.360 $\frac{19.}{\text{Torsion}}$		

Diameter of copper suspension wire 0.004". (0.0115 cm) length 32.5 cm
Torsional modulus of a sample of wire from the same spool
Length 26.398 cm. with copper sphere 2.54 diam = 1.27 radi. Mass 76.25 grms I = 449.18
Observed periodic time 9.205 secs.

Torsional modulus = $\frac{449.18 \times 26.4 \times 4\pi^2}{9.205^2 \times 4.303}$ = 605

Torsional moment for working wire = 605 / 32.592 = 18.57 cm. dynes per unit radian.



Transformer Tests with Differential Dynamometer.

The differential dynamometer was connected up as shewn on the opposite page. It was found that the direct passage component of the fixed coils affected the suspended opposite coils. This influence was only noticeable at or near full load current strengths but then amounted to several degrees of torsion. It was however quite possible to arrange the fixed coil lead so that their influence annulled their error, without altering the constants of the upper or lower suspensions.

The two constants were brought into equality by passing a current from a transformer secondary through the two fixed coils in series, and placing such resistances in the suspension circuits independently operated from the 120 volt secondary terminals that no deflection was observed on opening or closing the circuit.

These resistances of the suspension circuits that produced balance were Lower coil 1337 Lower coil 2267
Upper - 19,818 Ratio 8.838; and Upper - 19,940 Ratio 8.796

The transformer employed was the 80 ∞lt. Edison experimental transformer for whose design and modifications see Book V. p 111 & 112.
The resistance of the primary at start was 1.29 ∞ and during test taken at 1.24 ∞
- - - - - ∞ secondary - - - 0.03050 - - - - - 0.0382 ∞

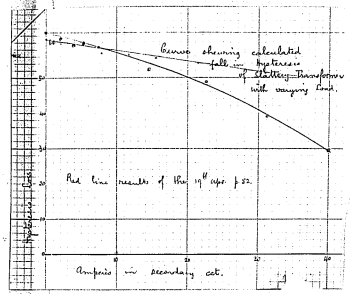
The following readings were observed. 8/1. 93.

Coils used were Upper #2 in primary ckt. Lower #2 in secondary.

No. of Obs.	Torsion	Pri. amp.	Pri. amp. Res.	Secondary Torsion Degrees. #1	Amplitude in degrees. Interval	Volts at Secondary terminals	Lamps c.c.	Res. in Sec. amp. ckt.	Constant K/R	Energy lost in transformer	8/r Loss.	Equivalent Hysteresis Watts + Calorie	Hysts.
1	147.5°	0.5	11,818 ∞	-		120	"	1337	2.7555	406	0.35	406	313
2	142	0.78		7.5° fin	2.51	120	6			391	1.09	390	297
3	142	1.05		32°	5.13	119	12			391	2.54	388	295
4	146	1.5		87°	8.53	118.5	20			402	5.90	396	303
5	150	2.81		41° max	19.30	116.5	49			413	25.21	388	295
6	158	4.06		97°	29.7	114.5	76			435	56.6	378	285
7	167.5	4.86		145°	36.31	113.5	95			461	73.7	387	294
8	146.5	0.5		0		120	-			402	0	402	311

The rate of hysteretic loss was also determined as follows:-
Upper dynes only in use.

Primary current	No. of Obs.	Secondary volts	r	Ave	Loss in Transformer	- 8/r	
4.5	1	122	142.5	2.7555	392.7	300	
"	2	118.5	139.5		384.4	291.4	
"	3	112.8	128.0		352.7	259.7	
"	4	109.2	118.5		326.5	233.5	
"	5	107.5	120.				
"	6	105.2	117		322.4	229.4	
"	7	102.3	111.5		307.2	214.2	
"	8	100.	109.		300.3	207.3	
"	9	98.	105.		289.3	196.3	


Curve showing calculated fall in hysteresis of Stalloy-Transformer with varying load.
Red line results of Plot 19" apr p 22
Amperes in secondary cct.

Transformer Tests with Differential Dynamometer 14th Apr.

Slattery Transformer. 20 light 1000 – 50.
Coil on dynamometer #2 upper in primary cct. #2 lower in secondary.
Res. of transformer coils Primary before test 9.38ω after test 10.4ω
Secondary " " 0.0444ω " " 0.034.4ω

Coil compensated for mutual influence at full load, and compensation checked after test.

Compensated balance of suspension cct: resistances with field coils in series 373ω in parts secondary & 19.500ω in primary cct.
E/I = 56.5

	T	F.D. at Sec. terms	Sec. Dyn. Scales ÷ 1	Sec. current m.a.	Primary current amp.	40 watt lamps in circuit	Re	δR	δX	Primary in lamps	Primary C²R + E/I	Hysteresis
	119.5	52.5	0	0	0.2	0	1.001	0.4	0	119.6	66.9	62.7
	118.5	"	6°	2.241	0.3	4		0.9	0.2	118.6	57.6	61.0
	119.0	51.9	0	0	0.2	0		0.4	0	119.1	56.9	62.2
	118.0	"	36.5	3.717	0.38	6		1.2	0.6	118.1	58.3	59.8
	119.0	"	0	0	0.2	0		0.4	0	119.1	56.9	62.2
	118.0	"	32°	5.177	0.36	8		1.4	1.2	118.1	59.1	59.0
	119.0	52.3	0	0	0.2	0		0.4	0	119.1	56.9	62.2
	119.5	51.5	69°	7.60	0.49	12		2.5	2.5	119.6	61.5	58.1
	118.5	52.0	0	0	0.2	0		0.4	0	118.6	56.9	61.7
	123.7	50.9	25.5	14.55	0.88	24		7.0	9.3	123.8	72.8	51.0
11	118.	52	0	0	0.2	0		0.4	0	118.1	56.9	61.2
12	145.5	50	56° comm	22.56	1.32	40		18.28	22.3	145.1	97.1	48.0
13	119.5	52.3	0	0	0.2	0		0	0	119.6	56.9	62.7
14	171.5	44.1	109°	31.33	1.77	55		82.85	43.1	174.6	133.5	39.
15	121.5	52.5	0	0	0.2	0		0	0	121.6	56.9	64.7
16	208.5	48.2	175.3	39.93	2.23	76		50.7	70.0	208.7	177.2	31.5

No of Hole	Weight 26th Apr	Weight 3rd May	Weight 18th May					
1	15.523	15.524						
2	17.237 (.001)	17.238 (.002)						
3	17.401 (.002)	17.391 (.002)						
4	17.520 (.001)	17.521 (.002)						
5	17.582 (.003)	17.584 (.002)						
6	17.659	17.690	17.690					
7	17.448 (.003)	17.394 (.002)						
8	17.185 (.002)	16.317 (.012)						
9	17.301 (.001)	17.302	0.001 17.300					
10	16.678	16.677 (.001)						
11	17.707 (.001)	17.470 (.001)						
12	17.606	17.606	17.607					
13	17.639 (.003)	17.642	17.644					
14	17.459 (.001)	17.455 (.003)	17.448					
15	17.438 (.002)	17.437	~~17.510~~					
16	17.436 (.010)	17.426 (.012)						
17	17.448 (.002)	17.449 (.002)	17.448					
18	17.522 (.001)	17.516 (.001)	0.000 17.512					
19	16.392 (.001)	16.393 (.002)	16.386					
20	16.421	16.420						

No of Hole	Weight 26th Apr	Weight 3rd May	Weight 18th May					
21	18.530	15.530						
22	18.132 (.016)	18.116						
23	17.030 (.002)	17.027						
24	17.964	17.962						
25	17.914	17.914						
26	17.231 (.002)	17.231	17.231					
27	18.838 (.002)	18.790 (.010)						
28	18.793	18.822 (.001)						
29	18.868	18.869	18.865					
30	19.082 (.001)	19.055 (.002)						
31	18.646	18.636 (.003)						
32	18.248	18.247	18.247					
33	18.209	18.210	18.212					
34	19.181	19.182	~~19.151~~					
35	18.218	18.222 (.010)						
36	17.979 (.002)	17.977 (.003)						
37	19.151	19.151	19.151					
38	18.699	18.691 (.002)	18.689					
39	18.893 (.002)	18.892 (.001)	0.001 18.891					
40	17.398	17.396 (.002)						

Experiments on the Chemical Corrosion of lead sheathing on Telephone Cables.

Telephone cable specifications call for 3% of tin alloyed with the lead in ~~the~~ sheathing. It was discovered, accidentally perhaps, that authors two leaden cables lay in the same wooden trough, one of ordinary lead, the other having 3% of tin, the latter resisted corrosion much more successfully. These were hot-press lead sheathings. Since that time the 3% has been insisted upon. There is as yet no evidence upon the behavior of Schenectady lead cold press sheathing and their longevity. It was found on trial at Schenectady that 1.5% or less of tin could be used without great difficulty, but 3% made the metal so hard that it could not be handled in the cold press.

In order to ascertain the amount of ~~lead~~ existing in Western Electric cables sheathing, a short piece was obtained, and sent with some other samples of Schenectady alloys to G. C. Moore the Newyork analyst see p. 48.

Twenty samples of lead from Schenectady with 1.5% tin, and twenty samples of Western Electric lead, all having the same dimensions 3.12 X 1.6 were cut to gauge, filed, and weighed. They were then immersed each in a separate solution.

No. of plate		Solution	Weight Apr. 14th	Weight Apr. 14th	Weight Apr. 22nd	Weight Apr. 14th	Weight Apr. 18th	Weight Apr. 22nd
1	21	5% Arsenious acid in H_2O	15.521	0.002 15.519	15.523	19.525	18.527	18.529
2	22	5% Cresote	17.306	0.014 17.292	0.010 17.266	18.132	0.002 18.130	0.001 18.125
3	23	5% Wood Tar oil	17.425	0.005 17.420	17.412	17.046	0.006 17.040	0.008 17.038
4	24	250 c.c. sat. H_2O containing CO_2	17.521	0.001 17.520	17.521	17.962	17.964	17.962
5	25	250 c.c. K_2CO_3 sat. sol.	17.587	0.002 17.585	17.587	17.913	17.911	17.915
6	26	5% H_2SO_4 in H_2O	17.684	17.688	17.689	17.223	17.230	17.231
7	27	5% Acetic acid in H_2O	17.551	0.003 17.518	0.003 17.514	18.930	0.002 18.900	0.060 18.870
8	28	1% HNO_3	17.249	0.000 17.210	0.145 17.145	19.132	0.002 19.130	0.029 18.838
9	29	5% Na_2S	17.303	0.002 17.301	17.304	18.865	18.868	18.869
10	30	5% H_2SO_3	16.423	0.004 16.419	0.013 16.410	19.063	19.064	0.001 19.062
11	31	5% $Na_2(HO)$	17.521	0.018 17.503	0.029 17.492	18.739	0.013 18.726	0.031 18.708
12	32	5% Na_2SO_4	17.599	17.602	17.606	18.239	18.246	18.247
13	33	5% Alum	17.642	0.004 17.638	0.12 17.640	18.204	18.206	18.206
14	34	Crude Carbolic acid	17.593	0.065 17.582	0.054 17.528	19.180	19.182	19.183
15	35	5% HCl	17.480	0.034 17.446	0.042 17.439	18.242	0.028 18.214	0.028 18.210
16	36	5% Bicarbonate of Soda	17.444	0.018 17.431	0.012 17.435	17.986	0.006 17.980	0.006 17.980
17	37	5% NH_4HO	17.453	0.006 17.447	0.002 17.449	19.149	19.150	19.152
18	38	5% NH_4Cl	17.537	0.000 17.533	0.006 17.531	18.695	18.701	18.707
19	39	5% $NaCl$	16.388	16.390	16.393	18.892	18.894	18.894
20	40	5% sol. of Fe_2O_3, Cr_2O_3 Al_2O_3	16.423	16.423	16.425	17.400	17.400	17.401

On the 16th the apparent corrosion were as follows:-

20	bad	40	bad
18	v.v. distinct	38, 28, & 24	distinct
10	marked	26	marked
11, 9, 11	slight		

They were removed, dried, weighed and replaced on the 18th

Tests for Corrosive Action of Lead carb.

Twenty more plates were cut from good Schemeckaty lead unalloyed, and were superficially coated with sulphate before drying and weighing by immersing in strong H_2SO_4.

No.	Weight 4th Apr.	Weight 25th Apr.	Weight 26th Apr.	Weight 27th Apr.	Weight 28th Apr.	Weight 29th Apr.	Weight 12th May.
1	22·780	22·785	22·785	22·785	22·785	22·785	22·785
2	13·320	13·322	13·322	13·322	13·322	13·322	13·322
3	13·090	13·092	13·092	13·092	13·092	13·092	13·092
4	13·220	13·220	13·220	13·220	13·220	13·220	13·220
5	13·210	13·211	13·211	13·211	13·211	13·211	13·211
6	12·890	12·892	12·892	12·892	12·892	12·892	12·892
7	13·370	13·373	13·373	13·373	13·373	13·373	13·373
8	13·490	13·492	13·492	13·492	13·492	13·492	13·492
9	13·390	13·396	13·396	13·396	13·396	13·396	13·396
10	13·350	13·357	13·357	13·357	13·357	13·357	13·357
11	12·840	12·847	12·847	12·847	12·847	12·847	12·847
12	13·160	13·167	13·167	13·167	13·167	13·167	13·167
13	13·160	13·165	13·165	13·165	13·165	13·165	13·165
14	13·160	13·165	13·165	13·165	13·165	13·165	13·165
15	12·780	12·784	12·784	12·784	12·784	12·784	12·784
16	13·220	13·223	13·223	13·223	13·223	13·223	13·223
17	12·670	12·665	12·665	12·665	12·665	12·665	12·665
18	12·960	12·957	12·957	12·957	12·957	12·957	12·957
19	12·900	12·897	12·897	12·897	12·897	12·897	12·897
20	13·450	13·437	13·437	13·437	13·437	13·437	13·437

These plates were immersed in distilled water, as those on the preceding page.

As it is mentioned in a text-book on Alloys that lead is readily corroded by water containing free CO_2, the lead carbonate being soluble in such liquid, and also that it is corroded by an aqueous solution of acetic acid, it was decided to try these two liquids specially.

8 plates were cut as follows..

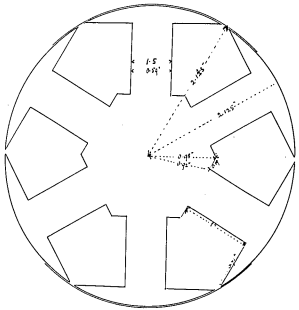
2 of pure Schemeckaty lead in CO_2 water + 2 do: in 5% acetic acid

2 - solder bar from storeroom - - - - 2 - 5% - -

No. of Plate	Metal	Stamped	Solution	Weight 16th Apr.	Weight 21st Apr.	Weight 25th Apr.	Weight 13th May	
1	Solder	41	5% Acetic acid in H_2O	22·955	22·941 (·014)	22·927 (·028)	22·872 (·083)	
2	"	42	Saturated CO_2 water 20 oz	16·535	16·531 (·004)	16·530 (·005)	16·525 (·010)	
3	Lead	41	5% Acetic acid in H_2O	27·370	27·330	27·323 (·047)	27·320 (·050)	
4	"	42	Saturated CO_2 Water	25·930	25·930	25·924 (·006)	25·920 (·010)	
5	Solder	41 a	50% Acetic acid H_2O	12·295	12·279 (·016)	12·265 (·030)	12·167 (·128)	
6	"	42 a	Saturated CO_2 water	7·640	7·636 (·004)	7·630 (·010)	7·630 (·010)	
7	Lead	41 a	50% Acetic acid H_2O	26·920	26·840 (·080)	26·785 (·135)	26·585 (·335)	
8	"	42 a	Saturated CO_2 water.	29·120	29·110 (·010)	29·085 (·035)	29·025 (·095)	

Twenty more plates were cut from good Schemeckaty lead unalloyed and were superficially cleaned, weighed and immersed on the 19th inst. in company with those on the top of this page.

No.	Weight 19th May.	Weight 20th Apr.	Weight 21st Apr.	Weight 22nd Apr.	Weight 23rd Apr.	Weight 24th Apr.	Weight 25th Apr.
1	12·877	12·875	12·875	12·875	12·875	12·875	12·875
2	13·200	13·198	13·198	13·198	13·198	13·198	13·198
3	12·960	12·958	12·958	12·958	12·958	12·958	12·958
4	13·240	13·238	13·238	13·238	13·238	13·238	13·238
5	13·210	13·210	13·210	13·210	13·210	13·210	13·210
6	12·855	12·856	12·856	12·856	12·856	12·856	12·856
7	13·360	13·361	13·361	13·361	13·361	13·361	13·361
8	13·465	13·467	13·467	13·467	13·467	13·467	13·467
9	13·376	13·378	13·378	13·378	13·378	13·378	13·378
10	13·347	13·347	13·347	13·347	13·347	13·347	13·347
11	12·770	12·771	12·771	12·771	12·771	12·771	12·771
12	13·158	13·158	13·158	13·158	13·158	13·158	13·158
13	13·172	13·172	13·172	13·172	13·172	13·172	13·172
14	13·147	13·147	13·147	13·147	13·147	13·147	13·147
15	12·780	12·780	12·780	12·780	12·780	12·780	12·780
16	13·210	13·210	13·210	13·210	13·210	13·210	13·210
17	12·665	12·662	12·662	12·662	12·662	12·662	12·662
18	12·952	12·953	12·953	12·953	12·953	12·953	12·953
19	12·892	12·892	12·892	12·892	12·892	12·892	12·892
20	13·435	13·435	13·435	13·435	13·435	13·435	13·435



Amended Design for a Battery Fan Motor from page 43.

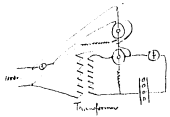
Power	=	5 watts
Speed	=	900 r.p.m. = 15 per sec.
Battery employed	=	4 cells Edison Lalande, 300 amp.hr type.
E.M.F.	=	2.67 volts @ 0.6 volts per cell.
Current	=	4 amp.
Res: of battery	=	4 × 0.0350 = 0.14 ω
Drop in battery	=	0.56 volts.
P.D. at terminals	=	2.12 volts
Resistance of leads	=	0.03 ω
P.D. at motor terms	=	2.00 volts
E.M.F. of motor	=	1.3 volt
Drop in Turns	=	70 ω. each limb 420 in all. allowed to 36 on each limb = 216 turns in all
		0.7 "
Res: of "	=	0.175 ω
" " armature	=	0.40 ω.
" " field	=	0.07 ω.
Type of armature	=	Lin - limbed.
1 line through limbs	=	20,000 c.c.s. in each successively.
Cross-section of limb	=	1.5 × 1.5 = 2.25 cm²
Effective " "	=	2.0
Polar surface	=	5.5 × 1.5 = 8.25 cm²
Entefer	=	0.020" = 0.05
Air reluctance	=	0.1/8.25 = 0.0121
MMF needed	=	262 for air say 250.
Exciting power	=	200
Turns at load	=	50 say 54. altered to 88
Core of field magnet	=	cast iron.
Intensity in core	=	5000
Leakage factor	=	1.3
Total armature flux	=	26,500 at max. in successive intervals
" field	=	42,000
Section of field	=	8.4 sq. cm
Diameter " "	=	3.3 cm. = 1.33".
Length of mean arm turns	=	0.3'
" " arm. winding	=	126' altered to say 100
Res: of armature wire	=	0.256 ω @ 20°C
" " " "	=	0.097 ω.
Size of " "	=	# 17 B.W.G 0.058" s.c.c. 0.065".
Interflange of armature	=	1" allowing of 15 turns.
Weight of arm: wire	=	1.27 lbs. 18 oz. 12 g.
Diameter of field	=	1.3"
Wire " "	=	4.19' = 0.35'
Length of wire	=	20'.
Resistance " "	=	0.07 ω
Size " "	=	# 17 B.W.G. 0.058" c.c.c. 0.065". # 15 B.W.G
Weight	=	0.2 lb. = 10 g.
Total weight of wire	=	1.6 lbs. on motor.

As actually constructed, the resistance of the armature @ 14°C = 0.122 ω
" " " " field 0.071 ω.

With an EMF of 6.75 volts at terminals and 2 amp. the speed was 1640 r.p.m.
+.25 and ω strong field of 5.75 amp. in field coils
6.50 ω give 1640 r.p.m.

The clearance is 0.015" = 0.037 cm.

Field altered to 140' of # 15 B.W.G. s.c.c., & armature winding reduced to 36 turns on each limb



Measurements of Transformer Losses by Dynamometer.

Constant of #3 upper coil.
Fixed #3 & suspension in series with voltmeter 50.75 volts 1035 ω = 0.014904 amp
45° Mercury $c_c = 2.405 \times 10^{-3}$ $c_c/r = 5.01 \times 10^{-5}$

Instrument compensated.
Balance with 3720 ω in sec. and 19.480 ω in pr. ckt. Ratio. 5.236
Constant of lower coil #3 from this balance 2.623×10^{-5}

Slattery transformer. Res. after test of primary) 10.308 ω of secondary) 0.014 ω.

No. of Obs.	τ	Pr. Amp.	Sec. Dyn.	Sec. Amp.	Lamps	Sec. P.D.	Sec. Energy	Ra	Energy in Pri.	c^2R	C^2r	c^2R+C^2r	Heat + Calcs.
1	61°	?0.10	–	–	–	33	–	1.0	61	0.1	–		61
2	60.5°	0.25	5°	2.046	3	53	108.5		60.5	0.6	0.2	0.8	59.7
3	61°	0.3	20°	4.092	6	52.8	216		61	0.9	0.7	1.6	59.4
4	61.5	0.4	74°	7.872	12	52.3	412		61.5	1.7	2.5	4.2	57.3
5	63°	0.6	162°	11.72	18	52.3	613		65	3.7	5.6	9.3	56.7
6	72°	0.8	290°	15.58	25	51.8	807		72	6.6	10.	16.6	55.4
7	85°	1.1	50° c.	21.32	36	51.5	1098		85	12.5	18.6	31.1	53.9
8	119.5	1.68	105°	30.9	50	49.9	1542		119.5	29.1	39.2	68.3	51.2
9	143.5	1.95	142°	35.92	66	49.3	1778		143.5	39.2	52.9	92.1	51.4

No compensation after test imperfect and results Pri. not reliable

Stanley transformer. Res. after test, of pr. = 10.577 ω of sec. = 0.011 ω
Balance with 3735 ω in sec. and 19.480 ω in pr. ckt. Ratio 5.215
Constant of lower coil #3 from this balance 2.61×10^{-5}

No. of Obs.	τ	Pr. Amp.	Sec. Dyn.	Sec. Amp.	Lamps	Sec. P.D.	Sec. Energy	Ra	Energy in Pri.	c^2R	C^2r	c^2R+C^2r	Heat + Calcs.
1	91°	0.1 ?	–	–	–	52.4	–	1.0	91	0.1	–		90.9
2	91°	0.25	5°	2.046	3	52.4	107	∈	91	0.6	0.1	0.7	90.3
3	92°	0.3	20°	4.092	6	52.3	214		92	0.9	0.2	1.1	90.9
4	93°	0.4	73°	7.818	12	51.6	404		93	1.8	0.7	2.5	90.5
5	95°	0.6	157°	11.46	18	51.5	590		95	3.8	1.4	4.5	90.5
6	99°	0.79	279°	15.28	25	51.0	779		99	6.8	2.6	9.4	89.6
7	110°	0.13	50° c.	21.32	36	50.3	1072		110	15.5	5.0	19.5	90.5
8	127.5	1.55	89°	28.44	50	50.	1422		127.5	27.2	8.9	36.1	91.4
9	155°	2.00	125°	36.20	66	49.6	1800		155.	45.3	14.5	59.8	95.2

Compensation after test o.k. Good series

Measurement of Transformer Losses continued. 25th Apr

Instrument compensated
Balance of #3 upper and #3 lower coils obtained with 3725 in lower, 19520 in upper circuit. Ratio 5.240
Repeated test of p. 47 with 80 light experimental transformer.
Resistance of primary coil with leads and ammeter 2.386
" " secondary " alone 0.0395

No.	T	Pr. Amp.	Pr. Amp.	c.M.	Sec. R	Energy in transformer	Sec. Amp.	Amp	Lamp	6th	Total Clk. energy	Sec. P.D.	Hysteresis
1	306	-	0.45	0.5	1.00	306	-	-	-		0.5	12.1	305.5
2	305	-	0.7	1.2		305	7°	2.745	6	0.3	1.5	12.1	303.5
3	306	-	1.45	5.0		306	64°	7.32	19	2.1	7.4	12.1	298.9
4	313.0	-	1.95	9.0		310.0	198°	12.88	20	6.6	15.7	118.7	294.3
5	305.5	-	0.45	0.5		305.5	-	-	-	-	0.5	12.1	305.0
6	323.5	46°	2.55	15.5		323.5	346°.	17.73	45	12.4	27.9	117.8	295.6
7	390.	145°	4.53	49.0		390	1'25°.	33.70	89	44.9	93.9	114.0	295.1

The compensation was checked after the test
The variation of the hysteresis + Eddy) loss with the terminal p.d. was also repeated as follows:-

No. of Obs	Sec. P.D.	Pr. Amperes	T	Rc	Pr. Watts.	$(P.D.)^2$	y		
1	60.5	0.3	102	1.00	102	709	0.1439		
2	70.2	0.32	130.5		130.5	900	0.1450		
3	80.1	0.33	158		158	1110	0.1422		
4	90.2	0.35	197		197	1343	0.1392		
5	100.	0.38	218.5		218.5	1586	0.1378		
6	110.1	0.4	252.5		252.5	1857	0.1360		
7	120	0.4	295		295	2122	0.1390		

Tests of Edison - Lalande Battery for Local Action

40 cells of the 150 Amp. hr. type were set up in two series of twenty cells each on the 21st April. The weights of the zinc plates of which there are two in each cell were obtained. The first series were set up in the usual way. The second series were set up with zinc plates to which amalgamated copper rods had been attached. These cells were all left on open ct. They contained some 1850 c.c. of NaHO solution of density 1.26 at 88° C.

No. of plate	Weight 21st Apr.	Weight 28th May	Weight 30th June	Weight 4th Aug.			No. of plate	Weight 21st Apr.	Weight 28th May	Weight 30th June	Weight 4th Aug.	Weight 2nd Sept.	
1	177.	176	169.5	163.5			1	150.5	149.5	146.0	141.5	131	
2	164.5	163.2	162.5	157.5			1 A	139	138.2	135.0	131.7	124.8	
3	173	172	168.5	166			2	148.5	141.7	138.0	80.5	76	
4	173.5	172.2	167.5	162.5			2B	149.5	148	144.0	80.5	74	
5	168.5	167.5	163.0	158			3	133.2	132.6	129.0	129.5	121	
6	167.2	165.7	164.5	156			3C	142.	141.1	142.5	142.0	122	
7	172.	168.7	164.5	162.7			4	127.	126.2	124.0	123	116	
8	182.5	183.5	178.	173.5			4D	137.	136.2	131.5	131.5	125	
9	184.7	182.	181.	177			5	141.	141.1	136.	135.	118	
10	174.	173.3	171.5	170			5E	143.5	140.	137.	130.	120	
11	167.3	166	157.5	156.5			6	124.5	123.4	122.5	128	120	
12	170.5	169.3	166.5	165.			6F	139.5	137.6	136.5	136	123	
13	176.	175.5	173.5	170.7			7	142	141.8	140	139	128.5	
14	173.5	173.	171.5	169.2			7G	138.3	137.3	137.	134	125	
15	176.7	176.	171.5	162.2			8	144.5	143.5	139.5	×		
16	171.3	170.5	166.5	160.7			8H	136.9	135.7	133.5	129.5	119	
17	175.7	174.8	172.5	168.			9	137.	136.	132.5	132.0	125	
18	179.2	178.2	172.0	161.2			9I	143.5	142.2	138.			
19	176.5	175.7	172.5	166.7			10	146	144	139.	135	126	
20	176.	175.2	172.0	165.5			10 J	135	133.8	131.	127.5	121	
21	170	169.	168.5	156.5			11	140.7	137.3	134.5	129.5	120	
22	171.5	170.5	166.5	157.2			11K	139.5	136.5	132.0	128.5	119	
23	173.5	172.2	165.5	163			12	149.7	145	139.0	134.5	124	
24	173.5	172.5	165.5	162			12L	142	138	131.5	126.0	126	
25	170.2	169.5	165.0	161			13	131.7	125.5	119.5	115.5	110	
26	167	166.2	160	157.5			13M	129.2	126.3	117.5	112.	108	
27	~~[illegible]~~						14	133	131.3	126.	122.	114	
28	~~[illegible]~~						14N	155.2	153.7	144.5	139.	128	
29	170.7	170.	165.5	157.5			15	128	126.	117	105.5	101	
30	177.0	176.3	174.5	149.5			15O	139.5	137.2	130.	121.0	111	
31	167	166.5	157.5	152.0			16	132	128.7	124.	115.0	106	
32	167	166.2	157.5	151.0			16S	132	129.3	125.	117.5	111	
33	176	175	162.5	163.5			17	143.7	141.7	136.5	130	×	
34	181.8	180.5	179.	171.5			17T	129.2	127.5	122.5	122.		
35	169.5	167	164.5	156.5			18	143.5	141.5	133.	×		
36	166.5	166.	158	155.5			18P	142.0	137.2	131.5			
37	171.	170.5	161.5	151			19	146.7	144.5	140.5	136	120	
38	192.2	191.7	172.	173			19a	145	144	137.5	132.	125	
39	173.	172.2	165.5	160.5			20	139	137.7	130.0	×		
40	178.7	177.5	171.0	165.0			20U	142.2	140.0	125.5			
Add 0.2 for lost							Add 0.8 for lost						
	6598.5	6564.9	6354.5	6168.1				5588.0	5508.2	5263.0			
Total loss		33.6	210.4	186.4					79.8	245.2			
Loss per plate		0.884	5.54	4.91					1.97	6.13			
Loss per cell		1.768	11.08	9.82					3.94	12.26			
			244.0	430.4						32.5			
			6.42	11.32						8.12			
			12.84	22.64						16.24			

Experiments on the corrosion of lead anti.

Two lead plates – Schemetzdorf unalloyed – were weighed on the 20th April and immersed in separate solutions. Their surfaces were (practically) equal to those of all preceding samples.

No. of Plate	Solution	Weight 20th apr.	Weight 25th apr.	Weight 29th apr.	Weight 13th May	
49 P	Carbolic Acid	13.166	13.111 (-.055)	13.061 (-.105)	13.005 (-.161)	
50 P	" "	13.320	13.296 (-.024)	13.283 (-.037)	13.085 (-.235)	
51 P	Flow rycast water	13.248	13.248	13.248	13.247 (-.001)	
52 P	" - - -	13.023	13.023	13.023 (+.000)	13.020 (-.003)	
53 P	Alcohol methyl	13.284	13.180 (-.104)	13.053 (-.231)	12.765 (-.519)	
54 P	Naphthalene in methyl alcohol	13.212	13.130 (-.082)	13.063 (-.149)	12.965 (-.247)	

A series was tried with block tin sheet, cut into strips with about the same area of surface as all the other samples.

No. of Plate	Solution		Weight 21st apr.	Weight 25th apr.	Weight 29th apr.	Weight 14th May	Weight 19th May	
50	5% Creosote in H_2O	10	0.788	0.788	0.789	0.788		
51	5% Wood Tar oil "	5	0.709	0.711	0.710	0.709		
52	250 c.c. ad Boil Water	11	0.802	0.802	0.803	0.803		
53	25% H_2SO_4 in H_2O ~~250 c.c. H_2O and $CaCO_3$~~	6	0.706	0.775 (+.069)	0.766 (+.060)	0.758 (+.052)	0.056	0.728
54	5% Acetic acid . .	7	0.765	0.727 (-.038)	0.791 (+.026)	0.761 (-.004)		
55	1% HNO_3 . .	8	0.706	0.776 (+.070)	0.770 (+.064)	0.769 (+.063)		
56	5% Na_2S . .	9	0.838	0.838	0.836 (-.002)	0.837 (-.001)	0.001	0.837
57	5% H_2SO_3 . .	10	0.818	0.819	0.818	0.818		
58	5% Na HO	11	0.760	0.760	0.757 (-.003)	0.758 (-.002)		
59	5% Na_2SO_4	12	0.747	0.746 (-.001)	0.746 (-.001)	0.745 (-.002)	0.001	0.746
60	5% Alum	13	0.846	0.845 (-.001)	0.845 (-.001)	0.845 (-.001)	0.001	0.844
61	Crude cor. Creosote	14	0.771	0.770 (-.001)	0.770 (-.001)	0.770 (-.001)		
62	5% HCl in H_2O	15	0.819	0.798 (-.021)	0.726 (-.093)	0.581 (-.238)		
63	5% Carbolate of soda	16	0.732	0.731 (-.001)	0.722	0.731 (-.001)		
64	5% NH_4HO	17	0.789	0.788 (-.001)	0.789	0.788 (-.001)	0.001	0.788
65	5% NH_4Cl	18	0.682	0.681 (-.001)	0.681	0.679 (-.003)	0.002	0.679

No. of Obs.	Time	Blank	Current in motor	P.D. on motor terms.	Energy in motor	R. of field	Drop in field	Energy in field	Energy in [illegible]
				4.956					
1	14.0		1			20.4			
2	.0	0.089	0.1664	483.5	224		9.3 v.		
3	.03	0.093	0.1433	547	237		8.7.		
4	.10	0.117	0.1677	547	233		12.2.		
5	.12	0.139	0.719	542	390		14.4.		
6	.20	0.159	0.928	547	453		16.6.		
7	.22	0.192	1.00	547	547		20.		
8	.32	0.215	1.12	547	613		22.4.		
9	.35	0.231	1.203	532	640		24.1.		
10	.37	0.251	1.308	532	696		26.2.	34.2	662
	.0		0.26	500	130		5.2.		

Constant of Differential Dynamometer 22nd Apr. 92.

(56)

Five measurement were made using the potentiometer to determine the currents, the Cosine of 2 coil + suspension, standard independent of the earth's field, and the standard meter strip 0.09945 legal v.

No. of Obs.	T	P.D. Stick on strip	C	Ratio on 1.0.7.6	a	C_a	C_a/T	Means	v	v^2	Result
1	147.°	0.3147	8.517	1.7214	0.03264	0.2950	2.007×10^{-3}	1.99956	0.009	8.1×10^{-5}	
2	267.5°	1.555	15.63	1.707	0.03430	0.5362	2.004		0.006	3.6	1.9985
3	270.5°	1.558	15.66	1.710	0.03437	0.5383	1.990		0.005	6.4	0.0007
4	271.°	1.5565	15.65	1.710	0.03437	0.5379	1.985		0.013	16.9	
5	171.°	0.9913	9.97	1.714	0.03444	0.3434	2.007		0.005	6.4	
										5.51.4	

Efficiency test of 500-volt ½ H.P. motor 21st Apr.

No.	Drop in mains	Eff. of conn.	Effort	Speed	Balance	Moment × 6165	Deducing	Loss in [illegible]
1/3 a				–	200 50 ⊕ −27			
				1810	50 ⊕ 3.8			
				2190	50 ⊕ 5.0			
				1900	50 ⊕ −8 500 ⊕ 5			
				1805	50 ⊕ 28.5 500 ⊕ 5			
				1795	500 ⊕ 10 50 ⊕ 10			
				1710	50 ⊕ 18 500 ⊕ 15			
				1650	50 ⊕ 20 500 ⊕ 20			
				1625	50 ⊕ −6 500 ⊕ 5 1000 ⊕ 10			
			598	1580	263	500 ⊕ 22 1000 ⊕ 10	9.7×10^7	255.4

N	Mean Depth of ring	Mean breadth of ring	Mean thickness of each plate	Mean thickness in inches	Mean B	$\frac{B}{2}$ in inches	β	$\frac{\beta}{2}$ + 1		
1	3.205	$\frac{5.07}{2}$	0.03023	0.0119"	16.020	0.11434	314.8	10570		
2	3.201	2.535	0.03138	0.01236"	16.680	0.1637	360.1	11.475		
3	3.214		0.036573	0.01438"	15.240	0.248	545.5	14.930		
4	3.214		0.03872	0.01524"	17.470	0.290	638.	16.480		
5	3.210		0.03116	0.01227"	15.630	0.1637	360.1	11.560		
6	3.208		0.03082	0.01213"	16.600	0.1546	340.1	11.030		
7	3.202		0.04104	0.01616"	16.440	0.332	734.7	17.900		

Particulars of Rings made up of sheet-iron annular disks received from Schenectady on the 25th April

Seven such series of samples were received. They were made up so as to have as nearly as possible the same weight.

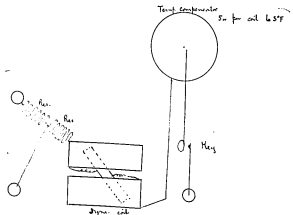
No.	Maker	No. of Disks	Int. diam.	Ext. diam.	Mean diam.	Mean Disk	No. of plates	Total mass	Mass per plate	Vol. of plates	Mean thickness in inches	Sp. g.
1	Edg. Williams	30	17.658 / 7.980	22.62 / 8.96	20.135	63.26	106	4010.6	37.84	514	8.124	7.8
2	Fuller. Bros.	30	"	"	"	"	102	4005	39.27	513.4	8.115	
3	Standard Iron Co	30	"	"	"	"	88	4021.	45.69	515.4	8.146	
4	P.H. Lanfranum?	28	"	"	"	"	83	4021	48.44	515.4	8.146	
5	Connecticut Corrugating Co	30	"	"	"	"	103	4016	38.99	514.8	8.137	
6	Charlton	30	"	"	"	"	105	4010	38.56	514.0	8.124	
7	Fuller Bros	28	"	"	"	"	78	4006	51.35	513.5	8.116	

Tests on the corrosion of lead cable sheathing.

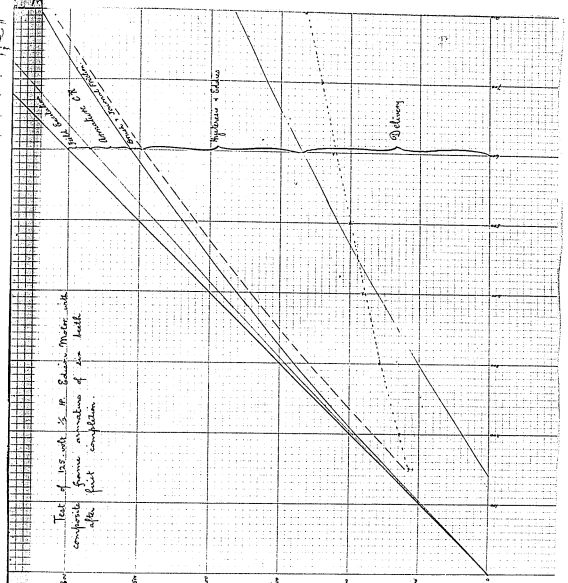
Samples of the standard dimensions were cut from pure chemically lead and immersed in different mixtures with excerts.

No. of Vessel	Solution	Weight 25th Apr.	Weight 29th Apr.	Weight 2nd May	Weight 13th May.	
100 P	Small admixture Naphtalene	15.812	15.813	15.812	15.812	
101	Small admixture of Na_2O to excerts	18.516	18.503 (.013)	18.478 (.038)	18.432 (.084)	
102	Large - - - - -	17.710	17.696 (.014)	17.674 (.036)	17.630 (.080)	
103	Small - - slaked lime $Ca(HO)_2$ - -	15.909	15.905 (.004)	15.898 (.011)	15.890 (.019)	
104	Large - - - - - - -	18.138	18.132 (.006)	18.115 (.023)	18.093 (.045)	
105	Small - - Na_2O + water - -	17.792	17.783 (.009)	17.773 (.019)	17.765 (.027)	
106	Fair treatment with Na_2Cl_2 - -	15.787	15.778 (.009)	15.760 (.027)	15.725 (.062)	
107	- - - ZnO - -	17.003	17.003	16.993 (.010)	16.970 (.033)	
108	- - - Baryles - -	16.568	16.565 (.003)	16.541 (.027)	16.535 (.033)	
109	- - - Litharge - -	12.833	12.808 (.025)	12.773 (.060)	12.707 (.126)	
110	- - - $Na\,Cl$ - -	16.431	16.428 (.003)	16.423 (.008)	16.412 (.019)	
111	- - cast iron filing - -	17.405	17.407	17.394 (.011)	17.382 (.023)	
112	- - H_2O aftermath sunnect -	15.811	15.793 (.018)	15.757 (.054)	15.780 (.031)	
113	- - H_2O from #12	13.051	13.045 (.006)	12.014 (.037)	13.020 (.031)	
114	Acetone	17.286 (before 25th)		17.282 (.004)	17.280 (.006)	
115	Orthocresol	17.678		17.674 (.004)	17.670 (.008)	
116	Metacresol	16.413		16.363 (.050)	16.310 (.103)	
117	Metaxylenol	12.676		12.648 (.028)	12.650 (.026)	
118	alpha naphthol dissolved in chloroform	15.883		15.883	15.880	
119	Beta - - - - -	17.486		17.468 (.018)	17.265 (.221)	
120	Rosalic acid - - H_2O	16.692		16.679 (.013)	16.680 (.012)	
121	H_2S water	17.141 (before 25th)		17.136 (.005)	17.130 (.011)	
122	Ammonium sulphide $(NH_4)_2S$	18.226		18.225 (.001)	18.230	
123	Ammonium sulphocyanide	17.055		17.040 (.015)	17.020 (.035)	
124	Concentrated solution of NH_4Cl.	20.040		20.013 (.027)	19.975 (.065)	

No.	Volts	Ohms	Current	Energy	No. of pole	Deflection field	Energy on field	No. of armature	Deflection armature	Torque armature	Speed of armature rps	Torque per rev.	Energy expended per rev.
1	12.5				4-4-4			220					
2	12.5	0.235	1.239	15.4		1.75	2.2		2.9	122.2	2410	40.1	3.5
3	12.5	0.205	1.89	14.1	1	2.23	3.5		3.58	119.2	2.100	35.0	3.605	5.7
4	12.5	0.368	1.92	24.0		2.69	5.2		4.32	118.0	1917	32.465	3.636	8.3
5	12.5	0.580	3.024	37.8		4.23	12.8		6.80	114.0	1740	29.0	3.930	20.5
6	12.4	0.775	4.041	50.1		5.66	22.8		9.09	109.25	1620	27.0	4.050	31.7
7	12.3	1.01	5.266	64.8		7.37	38.8		11.85	103.8	1530	25.5	4.070	62.3
8	12.2	1.20	6.255	76.4		8.76	56.9		14.08	99.2	1460	24.3	4.08	88.2



Moveable coil of aluminium wire ?
Field . . . copper .
Resistance . . German silver . ?



Test of 120 volt ½ H.P. Edison Motor 25th Apr. 92.

The motor was mounted on the floating cradle, and connected with the ½ H.P. G.+G. The resistance of the armature coil was 2.050 " " " " field " 1.27 "

Volt	Balances	Moment	Gross Moment	Decline	$\frac{f}{\text{Amp}}$	$\frac{f}{\text{Applied Aff}}$	Loss in Rot. Field & Arm	Lamps	Dynamo volts	output amps	Total Aff in watts	Total eff watts
	50 @ 14.5											
5.3	—	—	—	—	0		148.2	—				
9.8	{50 @ 1.2 / 1000 @ 1.0}	1825	1125×10⁻⁷	39.11	0.198	0.9574	150.4	6 G.G. light			5.81	9.2
15.5	{50 @ 10.3 / 500 @ 5.5}	4755	2.951	96	0.360	0.924	130.5	S.E.F.			7.01	13.5
24.7	{50 @ 21 / 500 @ 10.5}	8325	5.133	114.9	0.39	0.912	195.7	12			11.03	33.3
42.5	{50 @ 44 / 1000 @ 21}	13,175	8.122	219	0.437	0.881	221.5	32		2.4	16.75	59.5
71	{50 @ 92 / 1000 @ 46}	18,275	11.27	287	0.443	0.844	260	62		5.0	19.22	101.1
110	{50 @ 208 / 1000 @ 104 / 1000 @ 50}	23,350	14.39	348	0.455	0.813	273	102	37.8	5.2	22.84	143.1

The motor was driven from the G.+G., and without field the frictional moment was approximately 1000 cm.gm. = 0.6165 × 10⁷ or from 24 to 16 watts within the range of working speeds.

The effect of exciting the field of the Edison motor, still driven idle in the dark, with a current of 6 amperes, was to increase the moment up to 10 000 cm.gm. = 220 to 160 watts within the same range. It diminished slightly with the speed.

When iron wedges were inserted between the teeth of the armature, so as to present a closed magnetic circuit on the exterior, the moment increased to 16,000 cm.gm. when driven by the G.+G. with 6 amperes in the field. With brushes lifted 15,000 cm.gm. at

At 1250 r.p.m. 10,000 " "

The speed running light on 125 volt was 2230 r.p.m. at 1.7 amp.

Test of Weston Voltmeter 27th April 92. After Repairs

The instrument was examined, repaired, and then tested for its scale error by potentiometer as follows:— Instrument set to its indicated temp

Volts Indicated	Volts Measured	Error	Beyond on Measured Reading	Beyond on Measured by Potent.	Error
120	114.4	−0.6	6.0	60	+
117	116.7	−0.3	5.5	55.1	0.5
113	113	0.	5.0	50.5	0.7
103.6	107.9	+4.3	4.7	44.7	1.7
105.2	105.5	0.3	4.0	35.6	2.6
99.7	100.4	0.7	3.5	30.7	0.7
95.0	96.0	1.0	3.0	25.7	0.7
90.0	90.9	0.9	2.5	20.7	0.7
85.1	86.3	1.2	2.0	15.7	0.7
80.2	81.5	1.3	1.5	10.7	0.7
75.0	76.3	1.3	1.0	10.7	0.7
70	71.1	1.1			
65	66.2	1.2			
60	61.6	1.6			

Test of ½ H.P. motor with bridges connecting poles. 29th Apr.

Two wrought iron bridges were prepared bridging the polar gaps above and below, tapering to the centre where the breadth remains uniform, but the thickness reduces to about 0·2

124 volts.

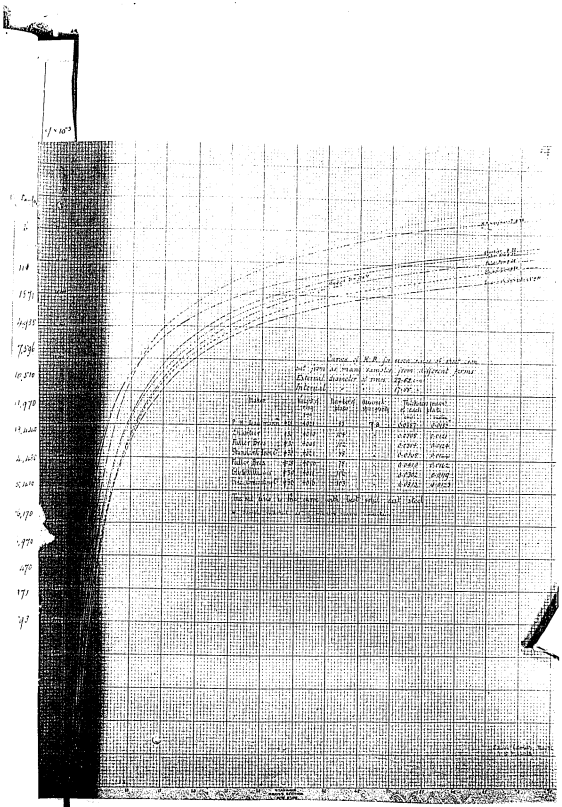
1st Test. Field separately excited with approx. 6 amp.

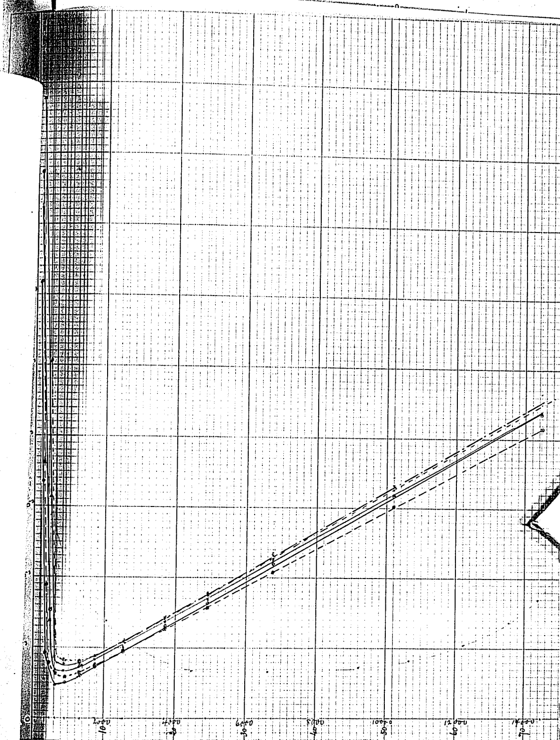
(1)	both bridges on	1783 r.p.m.	1·43	amperes in arm: 124 volts
(2)	upper off, lower on	1750 ..	1·49	- - - -
(3)	lower off, upper on	1750 ..	1·47	- - - -
(4)	both off	1715 ..	1·41	- - - -

2nd Test Self exciting 124 volts

(1)	both bridges on	2320 r.p.m.	1·03	amp. in motor
(2)	upper off, lower on	2310 ..	1·06	- - -
(3)	lower off, upper on	2340 ..	1·06	- - -
(4)	both off	2300 ..	1·11	- - -

				Fuller Bm #30					Gharlin #30					H.P. Comp	
Obsrd	Comp	H	Rev of q. ord	q	ξ	ρ	Thermr	q	ξ	ρ	Thermr	q	ξ		
0.032	0.145	0.859	5575	1.55	118.1	7273	17.5	1122	138.1	6.220	20.5	903	114		
0.155	0.343	2.285	30,275	16,650	2051	1.390	53	29,210	3575	0.793	93	18,210	1871		
0.115	0.595	3.057	30,275	36,130	4452	0.6924	115	53,710	6610	0.6471	171	40,210	4935		
0.1675	0.960	4.498	30,275	53,710	6618	0.6797	171	71,780	8834	0.5091	228.5	61,190	7596		
0.250	1.245	6.716	30,275	74,760	9212	0.7240	238	89,910	11,060	0.6073	286	85,610	10,510		
0.331	1.705	8.690	55,275	86,620	10675	0.8328	151	98,930	12,180	0.7300	172.5	97,500	11,97		
0.4375	2.443	12.72	55,275	99,220	12,230	1.040	173	107,800	13,270	0.9585	188	109,500	13,44		
0.690	3.560	18.53	55,275	110,000	13,550	1.368	191.8	115,300	14,190	1.306	201	118,000	14,4		
0.914	4.605	24.30	55,305	116,800	14,390	1.689	203.5	121,000	14,890	1.631	210.8	120,600	15,44		
1.260	6.502	33.84	55,305	122,800	15,130	2.237	214	124,800	15,360	2.203	217.5	121,700	16,17		
1.90	9.504	51.03	55,305	129,700	15,980	3.194	226	130,000	16,000	3.190	226.5	128,300	16,9		
2.69	13.90	72.26	55,305	133,800	16,480	4.391	233	134,900	16,600	4.359	235	142,300	17,0		
0.03	0.258	1.344	5,305	3.330	410	3.275	48	3,260	4,012	3.252	47	2020	37		
0.63	0.224	1.167	5,305	10,910	1344	1.255	171	14,960	1841	0.9164	234.5	7,273	8		




2000
4000
6000
8000
10000
12000
14000
10
20
30
40
50
60
70

Permeability Tests of Six Samples of Drain received from Schenectady Apr. 30th 1892.

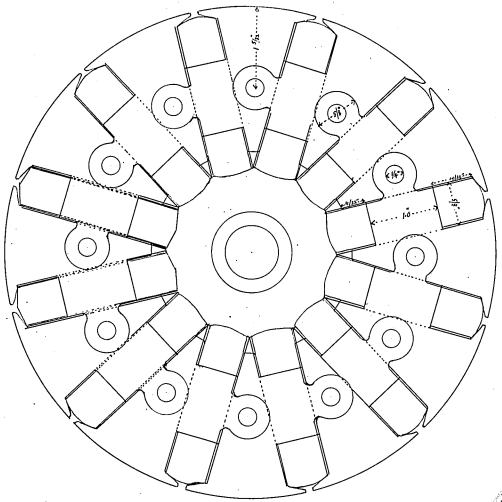
Galvanometer: 50 turns on each secondary. 262 turns on each pri.

Source of Line	EMF at beg.	Capacity	Mean throw	q	q per div	
Gallio 210	1.43114	1 μ	137.9	1.43114×10^{-9}	1.038×10^{-9}	
"	× Beg. of line # 30	×	Fullers Bros # 28	×	Environmental	Compositions #30

No.	Throw	q	k	ρ	Throw	q	k	ρ	Throw	q	k	ρ	Throw
1	16.5	794	97.7	8.792	4.5	547	67.4	12.75	10	739	90.8	9.461	13.5
2	48.5	7,352	905.5	3.137	23.5	4,555	561	5.079	114.5	8,109	984	2.896	25.5
3	12.8	26,740	3537.	0.5728	91.5	21,990	2909	1.140	70	25,920	3185	0.9694	82.5
4	197	46,800	5760	0.7809	114	44,390	5455	0.8245	141	45,390	5577	0.8065	144.5
5	272.5	70,210	8640	0.7773	223.5	65,550	8648	0.7950	218.3	68,600	8434	0.7964	218.5
6	170	81,740	10,060	0.8839	142.5	81,450	10,030	0.8855	142	81,160	9974	0.8913	141.5
7	191	95,210	11,720	1.085	166.	95,500	11,770	1.081	166.5	93,780	11,530	1.102	163.5
8	207	105,800	13,020	1.423	184.5	107,400	13,230	1.401	187.3	104,100	12,830	1.4444	182.
9	218.8	112,100	13,795	1.762	195.5	113,600	13,990	1.737	198	111,500	13,580	1.789	192.5
10	229.5	118,800	14,620	2.314	207	121,600	14,980	2.258	212	117,000	14,370	2.355	204.
11	241	125,100	15,400	3.314	218	127,800	15,740	3.243	222.8	124,800	14,840	3.439	210.5
12	248	130,200	16,020	4.517	227	133,500	16,440	4.401	232.5	127,300	15,630	4.620	221.5
13	435	1,660	204	6.589	24	1,210	149	9.020	17.5	1,570	230	5.893	27.
14	114.	3,031	373	4.523	47.5	2,201	271	6.224	34.5	3,733	459	2.676	58.5

Standard Curve G.

No.	Throw	Amp	H	Mag. g. cal.	q	k	ρ	Throw
1	0.095	0.491	0.9944	51.50	1885	231	10^{-3} 4.395	35.3
2	0.294	0.985	2.525	30.100	10,840	1319	1.316	50
3	0.777	0.913	4.753	30.100	25,170	6774	0.702	176.5
4	1.260	1.262	6.456	30.100	36,140	9246	0.748	223.5
5	0.352	1.516	9.476	31.100	50,100	14,230	0.564	255.
6	0.519	2.473	13.92	55.100	89,070	12,390	1.123	176.5
7	0.572	3.878	20.19	55.100	110,970	13,610	1.476	194.5
8	0.977	8.941	26.21	55.100	117,200	14,670	1.821	205.
9	1.414	7.248	37.98	55.100	124,100	15,200	2.1494	217.



New design for the 1/2 H.P. Composite Frame Armature

4th May 32.

Number of segments in arm:	12
Surface of each segment	4·5 X 2·5 = 11·25 cm²
Cross section of core	(2·54)² = 6·45 cm²
Entrefer	1/32" = 0·07934
Full load flux	200,000 useful C.G.S. lines in arm:
Useful armature flux density	15,500
Winding space in each section	0·5" × 0·625" × 1·5 × 1·588 = 2·38 sq. cm. 0·369 sq. in.
Space occupied by insulation	2·5" × 0·01" = 0·025 sq. in.
Space left available	0·344 sq. in.
Number of turns in section	176 in 120 volt motor ; 720 in 500 volt
Cross section of coated wire	(0·0442)² - - - - (0·021)² - - -
	0·001764 sq. in - - - 0·00044·1 sq. in - - -
Space occupied by wire	0·317 sq. in. 0·317 sq. in.
Local reluctance to one spool	$\frac{0.07934}{5.625} \times 2 = 0.0282$ "
Spool MMF	1·257 X 530 = 662
Local flux	23500
" B in arm: + pole face	4,173
Main flux density in pole face	5,330.

Tests on the corrosion of lead sheathing contd.

Plain Schenectady lead.

No. of plate	Solution	Weight 2nd May	Weight 6th May	Weight May 9th	Weight 24th May		
125	Aniline oil	16.625	16.617 (.008)		16.617 (.008)		
126	Pyridine	16.625	16.625		16.626		
127	Tap water	16.601	16.604		16.604		
128	Beech wood tar Creosote.	~~16.575~~ May 4th	16.576		16.581 (.006)		
129	Pure coal tar creosote	16.500		16.446 (.054)	16.378 (.122)		
130	" - - - -	16.720		16.664 (.056)	16.593 (.127)		
131	- - - - -	16.670		16.608 (.062)	16.537 (.133)		
132	Creosote treated with strong acid	16.400		16.376 (.024)	16.262 (.138)		
133	" - - - - -	16.745		16.732 (.013)	16.717 (.028)		
134	- - - - - -	16.745		16.738 (.007)	16.723 (.022)		

Test made of efficacy of Edison Transformer Patent.

May 6th

A commutator was made of the type represented in this patent. There were two low. pressure segments ~~rings~~, two high pressure segments and six battery segments, making in all 8 brushes and 3 batteries. 21 small storage cells were made up each of two lead plates 7×10 separated by ⅛". They were "formed" by charging and discharging a suitable number of times. The commutator made about 1750 r.p.m. It charged the three batteries of 21 cells in all for ⅙ of the whole time with a mean current of 2.5 amp. at 125 volts pressure, and then discharged the cells in 3 rows of 7 during nearly ⅚ of the whole time at a mean current of 5 amp. and 12.5 volts = 62.5 watts.

If the secondary circuit be interrupted, the current in the primary falls to 2.0 amp. showing that the supply of 0.5 amp. over and above this amount goes almost wholly into the secondary cct.

Experiments on heating creosote to render it inoperative on lead

No. of plate	Solution	Weight 13th May	Weight 14th May	May 18th	May 21st		
135	Creosote treated with $Cu\,Cl_2$	16.740	16.737 (.003)	16.726 (.014)	16.723 (.017)		
136	" - - - $Na_2\,SO_4$	16.740	16.740	16.735 (.005)	16.733 (.007)		
137	- - - - $Na\,NO_3$ and	16.595	16.585	16.569 (.026)	16.559 (.036)		
138	- - - $Na\,SiO_3$	16.720	16.690	16.664 (.056)	16.660 (.060)		
139	- - - - $Mg\,SO_4$	16.840	16.825	16.810 (.030)	16.804 (.036)		
140	- - 10% H_2SO_4 in H_2O	16.645	16.647	16.645 (.000)	16.644 (.001)		
141	- - - - $NH_4\,SO_4$	16.690	16.670	16.665 (.025)	16.659 (.031)		
142	- - - - $Na_2\,CO_3$	16.700	16.675	16.672 (.028)	16.668 (.032)		
143	- - - - Rosin	16.760	16.755	16.743 (.017)	16.738 (.022)		
144	- - - - $Fe\,O$.	16.665	16.660	16.648 (.017)	16.640 (.025)		
145	- - - - $Fe_2\,SO_4$	16.690	16.685	16.672 (.018)	16.662 (.028)		
146	- - - - $Mn\,O_2$	16.000	15.975	15.965 (.035)	15.932 (.068)		
147	- - - - $Sn\,Cl_2$	16.032	16.045	16.039 (.007)	16.037 (.005)		

The eddy current activity per sq. cm. of a thin iron sheet (thickness $2h$) of material submitted to a simple harmonic force H cos pt is

$$\frac{\rho m H^2}{16\pi^2} \cdot \frac{\sinh 2mh - \sin 2mh}{\cosh 2mh + \cos 2mh} \quad ; \quad \text{where } m = \sqrt{\frac{2\pi\mu p}{\rho}} = 2\pi\sqrt{\frac{\mu p}{\rho}}$$

In these experiments $p = 890$. ρ = say 1.1×10^{7} $\quad \therefore m = \sqrt{\frac{6.283 \times 2 \times 0.890 \times 10^{6}}{1.1 \times 10^{7}}} = \sqrt{1.0[illegible]}$

μ = . 2×10^{3} $\quad = 31.89$ say 32.

$$\frac{\rho m}{16\pi^2} = \frac{1.10 \times 3.2 \times 10^{6}}{160 \times 10^{6}} = 2.2 \times 10^{3}$$

For Ring #1 p. 57.	$2h = 0.0302$	$2mh = 0.9664$	$\frac{1.12 - 0.819}{1.497 + 0.574} = \frac{0.301}{2.071} = 0.1[illegible]$
2 . . .	$= 0.0314$	$= 1.0025$	$\frac{1.152 - 0.841}{1.543 + 0.540} = \frac{0.311}{2.083} = 0.1[illegible]$
3 . . .	$= 0.0365$	$= 1.168$	$\frac{1.4551 - 0.9288}{1.766 + 0.390} = \frac{0.5350}{2.156} = 0.248$
4 . . .	$= 0.0397$	$= 1.239$	$\frac{1.593 - 0.946}{1.872 + 0.325} = \frac{0.647}{2.197} = 0.29[illegible]$
5 . . .	$= 0.0312$	same as #2	$= 0.1[illegible]$
6 . . .	$= 0.0306$	mean of 1 + 2.	$= 0.150$
7 . . .	$= 0.04410$	$= 1.312$	$\frac{1.715 - 0.967}{1.955 + 1.255} = \frac{0.751}{3.246} = 0.23[illegible]$

for an exceedingly thin disk

$$W = \frac{4}{3\rho} H^2 \mu^2 p^2 h^2$$

$$= \frac{4 \times 4 \times 10^{6} \times 7.921 \times 10^{6}}{3 \cdot 3 \times 10^{7}} h^2 H^2$$

$$= 3.841 \times 10^{8} h^2 H^2$$

For #1 $h = 0.0151$ $\quad h^2 = 3.443 \times 10^{-4}$

$$W = 3.841 \times 3.443 \times 10^{-4} H^2$$

$$= 1.322 \times 10^{3} H^2$$

$$= 43,780 H^2 \text{ per c.c. exp.} \div 8 = 5,473 H^2$$

2.1 [illegible]

$$n\sqrt{\frac{\rho_p}{\rho}}$$

$$\frac{\sqrt{\frac{4\rho \times 10^3}{10^3}}}{} = \sqrt{[illegible]}$$

being 32.

$$\frac{0.3017}{2.071} = [illegible]$$

$$\frac{0.3361}{2.083} = [illegible]$$

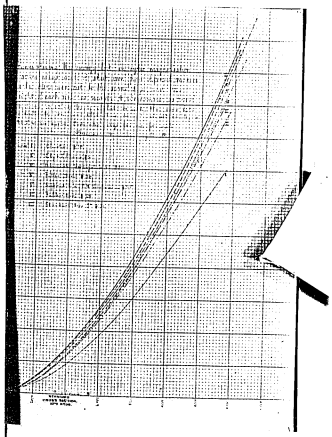
$$= \frac{0.3350}{2.086} = [illegible]$$

$$\frac{[illegible]}{} = \frac{0.4037}{2.197} = [illegible]$$

$$= [illegible]$$

$$= [illegible]$$

$$\frac{Z}{[illegible]} = \frac{0.7351}{3.246} = [illegible]$$



Tests of seven rings from Schenectady Steel iron.

262 turns on each ring. Tested with the new end of the single dynamometer 16th x.1917

	R	Rat	P.D. in ring	amp	ck.	EMF	B	cR	Watts in half cell	Watts per lb of iron		
						Charton #20						
										12,700		
22'	4440	1.25	13	0.25?	-	13	970	-	1.25	1717		
7.5		4.26	25	0.1	-	25	1866	-	4.26	355.3		
16.		9.09	40.4	0.2	-	40.4	3016	0.01	9.09	1248		
27		15.34	54.5	1.3	0.1	54.7	4083	0.03	15.34	2108		
40		22.73	71.3	0.35	0.1	71.2	5315	0.04	22.69	3118		
56		31.52	87.	0.40	0.1	86.9	6486	0.05	31.77	4365		
70.5		40.06	100.	0.46	0.1	99.9	7457	0.06	40.0	5495		
89'		50.57	115.	0.53	0.2	114.8	8569	0.08	50.69	6937		
109.5'		62.21	130.2	0.62	0.2	130.	9703	0.11	62.1	8532		
137.0'		79.54	151.	0.75	0.2	150.8	11,260	0.17	77.67	10,670		
160.5		91.20	169.3	0.93	0.3	169.	12,620	0.26	90.94	12,495		
197.5		106.2	190.3	1.39	0.4	189.9	14,180	0.57	107.63	14,790		
214.5		121.9	213.1	3.22	1.0	212.1	15,830	3.08	118.82	16,330		
						H.P. Confirmation 25				12,900		
10.5'	2050	3.09	17.25	0.2	0.07	17.18	1279	0.01	3.08	422.		
43.5'	2160	13.31	39.85	0.35	0.15	39.7	2956	0.04	13.27	1818		
66'	2600	24.31	59.5	0.44	0.15	59.35	4420	0.07	24.24	3221		
109'	2490	38.45	80.8	0.54	0.20	80.6	6000	0.10	38.35	5255		
171'	2220	53.79	100.7	0.62	0.28	100.5	7482	0.13	53.66	7352		
122'	4120	71.22	119.4	0.72	0.24	119.	8859	0.18	71.04	9734		
151'	4250	83.26	140.4	0.81	0.2	140.2	10430	0.22	83.04	11,380		
183.5	4090	106.4	157.2	0.96	0.3	158.9	11,830	0.31	106.09	14,540		
229.5	4150	134.9	175.9	1.20	0.4	175.5	13,060	0.49	134.41	18,420		
301'	4030	171.9	204.7	1.95	0.7	204	15,190	1.29	170.61	23,372		
						Julius Bros #28				13,700		
10'	2880	3.98	20.7	0.30	0.1	20.6	1539	0.03	3.95	543.		
39.5	2310	12.93	40.6	0.38	0.1	40.5	3027	0.05	12.88	1771		
89.5	2070	26.25	58.6	0.44	0.1	58.5	4372	0.07	26.18	3600		
128	2160	39.2	81.2	0.53	0.2	81.	6053	0.1	39.1	5376		
90.5	4250	54.5	99.8	0.68	0.2	99.6	7446	0.2	54.3	7468		
116.	4400	72.3	118.4	0.74	0.2	118.26	8826	0.2	72.1	9914		
120.5	4110	70.15	119.4	0.73	0.3	119.3	8900	0.2	69.95	9618		
149.5	4330	91.73	140.	0.87	0.3	139.7	10,440	0.3	91.43	12570		
180'	4560	116.3	157.6	1.08	0.4	157.2	11,750	0.4	115.9	15940		
269.5	4050	184.6	191.	1.84	0.5	190.5	14,230	1.2	153.4	21,090		
						Dr. Williams #30				16,700		
9.5'	2310	3.11	18.7	0.3	0.1	18.6	1388	0.03	3.08	423.5		
30'	2660	11.31	40.3	0.38	0.1	40.2	3,000	0.04	11.27	1550		
69.	2230	21.80	59.7	0.47	0.2	59.5	4441	0.07	21.73	2988		
98.	2510	36.95	81.1	0.57	0.2	80.9	6018	0.11	36.74	4777		
140.	2550	50.58	101.5	0.70	0.2	101.3	7561	0.16	50.42	6934		
103.5	4270	65.64	118.7	0.80	0.20	118.4	8337	0.22	65.42	8996		
144.5	4130	84.57	140.	1.0	0.3	139.7	10,430	0.34	84.23	11,583		
180	4110	104.8	161.	1.33	0.4	160.6	11,990	0.6	104.2	14,330		
214'	4080	123.7	184.5	2.02	0.7	183.8	13,720	1.4	122.3	16,820		

Tests of seven rings from Schenectady sheet. now.

Ring No.	τ	R	Rat	P.D. at ring	amp.	ch	Emf	B max	ch	Watts in hyst. coil.	Watts per sq. in. hyst. coil.		
Ring No. 1	10°	2620	3.73	20.6	0.3	0.1	20.5	1528	0.03	3.70	7,300 507.6		
2	25.5	2870	11.54	40.7	0.38	0.1	40.6	2026	0.05	11.54	1583.		
3	65°	2360	21.73	59.5	0.44	0.2	59.3	4420	0.08	21.65	2970.		
4	105°	2450	36.45	81.8	0.60	0.2	81.6	6030	0.12	36.33	4984.		
5	152	2375	51.11	99.9	0.70	0.2	99.7	7430	0.16	50.95	6990.		
6	113	4330	69.33	119.4	0.81	0.3	119.1	8876	0.22	69.11	9481		
7	144	4310	89.92	138.4	0.97	0.3	138.1	10,290	0.32	87.6	12,020		
8	183.5	4340	112.8	160.4	1.35	0.4	160.	11,920	0.6	112.2	15,390		
9	230.5	4110	131.2	179.8	1.90	0.6	179.2	13,360	1.2	130.0	17,830		
10													
Ring No. 2	12.5	2370	4.20	20.7	0.3	0.1	20.6	1534	0.03	4.17	2,900 571.3		
2	31.5	2240	12.58	40.5	0.40	0.1	40.4	3008	0.05	12.48	1710.		
3	70.5	2440	24.37	59.5	0.5	0.2	59.3	4415	0.08	24.29	3328.		
4	112.5	2370	38.44	79.8	0.6	0.2	79.6	5927	0.12	38.32	5251.		
5	168.5	2360	56.33	99.9	0.72	0.3	99.6	7416	0.16	56.17	7696.		
6	121.	4330	74.23	118.5	0.8	0.3	118.2	8801	0.22	74.01	10,140		
7	151.5	4450	95.52	140.4	0.96	0.3	140.1	10430	0.32	95.2	13,040		
8	186.5	4420	116.8	158.4	1.14	0.4	158.	11,360	0.4	116.4	15,950		
9	240	4230	143.8	180.2	1.5	0.5	179.7	13,380	0.8	143.0	19,090		
10	274	4200	163	193.7	1.89	0.6	193.1	14,380	1.2	161.8	22,170		
Fuller Ring No. 2	8.5	2560	3.08	18.2	0.3	0.1	18.1	1353	0.03	3.05	2,700 420.		
2	31.	2520	11.79	40.4	0.36	0.1	40.3	3012	0.04	11.75	1616.		
3	64.	2310	22.58	60.	0.45	0.2	59.8	4469	0.07	22.51	3097		
4	102.	2570	35.15	82.6	0.52	0.2	82.4	6158	0.08	35.07	4,825		
5	84	4180	44.75	99.2	0.60	0.2	99.	7398	0.12	44.63	6828		
6	110.5	4320	67.63	118.8	0.75	0.3	118.5	8856	0.19	67.44	9279		
7	150	4110	87.34	140.	0.89	0.3	139.7	10,440	0.27	87.07	11,980		
8	185.5	4160	109.3	159.6	1.10	0.4	159.2	11,900	0.4	108.9	14,980		
9	227.	4050	130.2	177.5	1.47	0.5	177.0	13,230	0.7	129.5	17,820		
10	260.	4150	152.9	196.3	2.05	0.7	195.6	14,620	1.4	151.5	20,840		

Test of three samples of Western Electric Lead.

	Solution	Weight May 5th	Weight May 20th			
150	Bone: waste	15.807	15.795 -.012			
151	- -	16.072	16.068 -.004			
152	- -	15.467	16.461 -.006			

No.	Type of cell	E mean	r mean	E²	E²/r	List price	E²/per.	Amp. Cap.			
1	Mason Wood	1·9	0·09	3·61	40·1			170			
2	Chromic-acid	1·8	0·15	3·24	15·0			30			
3	Fuller.	1·8	0·40	3·24	8·1	1·00	8·1	68			
4	W.W. Barton	1·8	0·4	3·24	8·1	1·25	6·48	5			
5	Gravity	1·0	0·5	1·0	2·0	0·90	2·22				
6	Leclanché	1·5	0·5	2·25	4·5	1·00	4·5	–			
7	Partz Nitric acid	1·83	0·51	3·35	6·6			63·5			
8	Hussey Sclipse	1·4	0·8	1·96	2·45	2·50		45			

Test of Edison-Lalande cells. May 92.

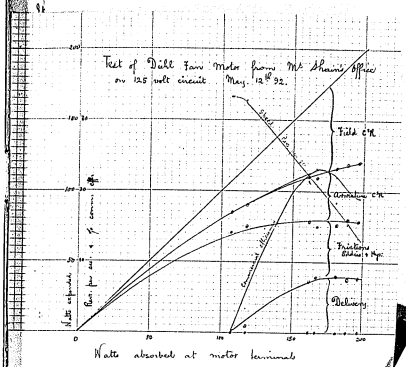
No.	Cell	Amp. Hrs.	Mean E.M.F.	Mean r	E²/r	List price	E²/per	Size of copper side	Zinc	Weight of Caustic lost by one charge
1	A	15	0·667	0·500	0·889	0·75	1·189	1 of 3"×3"	1	
	B	15	"	0·500	0·889					
2	C	50	0· "	0·180	2·470	1·15	2·148		1	
3	E	150	"	0·070	6·348	1·85	3·431	1 of 3"×4"	2	1 lb.
4	G	300	"	0·048	10·342	2·50	6·13	1 of 4"×4"	2	2 lbs.
5	K	"	"	0·025	17·78	2·50	7·11	2 of 3"×4"	2	2 lbs.
6	M	600	"	0·013	34·18	6·75	5·063	4 of 4"×4"	3	4 lbs.
7	F	150		0·020	22·22	-	-	4 of 3"×4"	3	
8	P	600	"	0·020	22·22	4·85	4·581	2 of 4"×4"	2	4 lbs.
9	T	900	"	0·018	24·70	6·25	3·951	2 of 4×4"	2	6 lbs.
10	N	50	"	0·100	24·70	-	-		3	
11	L	300	"	0·017	26·15	-	-	4 of 3"×4"	3	2 lbs.
12	D	40	1·333	1·0	1·778	2·50	0·711		2	10 oz.
			0·667	0·190	2·339					
B.	K								1	

Measurements made on the resistance of a Cautery battery or F cell. 10th May.

	Diagram	E	PD.	Amp.	C.	r
Plates removed from the square F cell and placed in the round K jar		0·669	0·565	0·104	5·65	0·018 ω
One outside zinc removed altogether		0·672	0·540	0·132	5·40	0·024 ω
Both outside zincs removed		0·671	0·482	0·189	4·82	0·039 ω
Center zinc removed and one outside zinc replaced		0·670	0·392	0·278	3·92	0·071 ω
Other outside zinc replaced, center still removed		0·670	0·442	0·226	4·42	0·051 ω
Copper electrode changed		0·670	0·436	0·235	4·36	0·053 ω
All three plates replaced		0·672	0·562	0·110	5·62	0·0197
Plates replaced in square F jar		0·672	0·535	0·137	5·35	0·0256

No. of Obs.	P.D. at terminals	Speed	Amps. thro' motor amp.	Energy in motor watts	Res. of field	Drop in field volts	Energy in field watts	Energy in arm watts	Res. of arm ohms	Drop in arm. volts
1	125	0·165	0·860	107·5	31 – ohm	26·66	22·9	84·6	19 – ohm	16·3
2	"	0·180	0·9385	117·3		29·1	27·3	90·0		17·8
3	"	0·250	1·303	162·9		40·4	52·6	110·3		24·9
4	"	0·256	1·335	166·9		41·4	58·2	108·7		25·4
5	"	0·279	1·455	181·9		45·1	65·6	116·3		27·6
6	"	0·289	1·507	188·4		46·7	70·4	118·0		28·6
7	"	0·302	1·574	196·8		48·8	76·8	120·0		29·9

When driving the 15" fan at regular 125 volt speed – 1470 r.p.m. the motor takes 1·20 amp or 150 watts.



Test of a Dühl 115 volt fan motor 12th May 92.

This motor was borrowed for test from Mr Sharin's office in New York.
Its weight is 21 lb. 5 oz with fan – no guard.
It drives a 6 bladed fan like the E.W., but with flat blades Diam. 12".
The armature revolves outside the field. Diam: of arm: 6.9" ext.
Wire: of armature 15.5 – 18.5 w. Field 29 w. Total 44.5 – 47.5 w. @ 18°C.
Running at 125 volts, with fan, it makes 1470 rpm, and takes 1.2 amp.
or 150 watts. The motor was mounted in the float and coupled to
the 1/16th H.P. Perret. Diam: of armature 6¾" on the outside.

Amp in	Centre EMF	Effort	Speed. rpm.	ft.	Balance	Moment	6160 Moment	Delivery	Efficiency Effort × Speed / Watts	Com. eff.	Cond.
	volts										
1	82	70·7	2000	13·3	50 –	–					Running light
	78·2	74·3	1960	32·7	50 @ 4	200	1233 × 10⁶	40·3	70·27	0·032	Comp'd. L. block
6	59·8	78·0	1280	21·3	20 @ 35 / 100 @ 10	2700	1·695 × 10⁷	36·15	21·8	0·227	S. E. Rust P.
9	58·2	74·8	1210	20·7	50 @ 40·5 / 100 @ 10	3025	1·865 –	38·6	36·2	0·231	Comp. on block
12	52·3	76·1	1100	18·3	50 @ 30 / 100 @ 20	3500	2·158 –	39·55	38·5	0·218	"
15	49·7	74·9	970	15·2	50 @ 37 / 100 @ 25	3950	2·435 –	37·0	37·9	0·196	"
18·0	46·3	73·0	800	13·5	50 @ 23 / 100 @ 10 / 100 @ 25	4650	2·866 –	38·2	34·8	0·194	–

Resistance of motor after test 50·5 – warm.
Motor packed and returned to Mr Sharin.

Test of Edison Model Motors.

Four Edison model motors were shipped to Lynn. Mass. on the 12th & 16th May, addressed to Mr E. Rice. The tests were as follows

Model	Wound for	R.P.M. at motor	Clock	Amp.	Watts	Speed	Work
1/32 H.P.	125 volts	125		0·35	44	1330	Driving 9" fan
	500	~~500~~ 500		0·09	45	1725	- - -
1/16	125	125		0·5	62·5	2120	Lifting ~~100~~ fan
	500	4·95		0·15	73	1385	Driving 12" fan

Experiments on rendering Creosote inactive on lead

No.	Treatment	Weight on Date 16th May	Date May 20th	
1168	Creosote heated with PbO	16·360	16·355 (·005)	
1169	"	16·178	16·172 (·006)	
1170	Na_2SO_4	16·128	16·128	
1171		16·121	16·121	
1172	10% H_2SO_4	15·860	15·861	
1173		15·883	15·884	
1174	NH_4OH	16·599	16·461 (·138)	

Motor driving 11½" fan. 6 blades

Slow. speed 1330 r.p.m. Black 0.106 Amp. 0.2547 120 volts 6.5.6 watts
High 1850 . 0.172 . 0.888 118.5 . = 105.2 watts

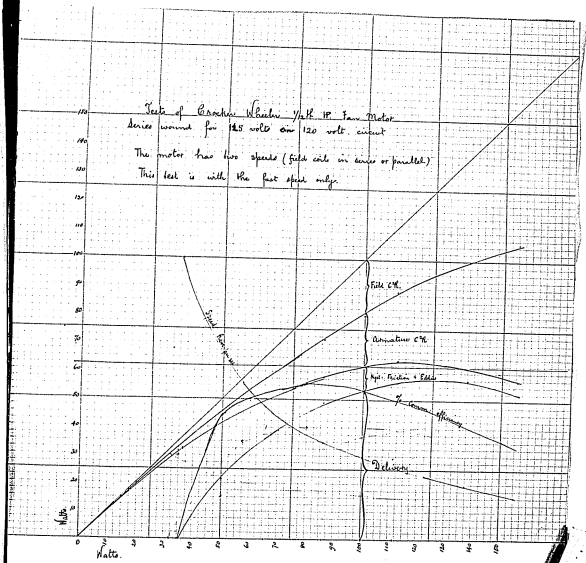
When fitted with Edison General 60° 9" fan with 6 blades

Slow. speed 2170 r.p.m. Black 0.060 Amp. 0.3096 118 volts = 36.5 watts
High " 3140 . . 0.100 . 0.516 120 . = 61.9.

No. of Obs.	P.D. at Motor terms	Black	Amp.	Energy in Motor watts	Rev. of field r.p.m.	Drop in field volts	P.D. at armature volts	Energy in field watts	Energy in armature watts	Rev. of armature r.p.m.	Drop in armature volts
1	12.6	0.055	0.287	36.2	25	7.2	118.5	2.1	34.1	25	7.2
2	12.6	0.032	0.167	21.0	100	16.7	109.3	2.8	18.2	.	4.2
3	12.5	0.05	0.261	32.6	-	26.1	98.9	6.8	25.8	.	6.5
4	12.5	0.103	0.537	67.1	-	53.7	71.3	28.8	38.3	.	13.4
5	12.5	0.112	0.584	73.0	-	58.4	67.6	34.1	38.9	-	14.6
6	12.3	0.05	0.261	32.1	100	26	96.9	6.8	25.5		
7	12.3	0.060	0.313	38.5	.	31.3	91.7	9.3	28.3	.	6.5
8	12.2	0.072	0.375	45.8	125	37.5	112.6	3.5	42.3	-	5.3
9	12.0.4	0.088	0.459	55.3	126	46.9	108.5	5.5	49.8	26	2.4
10	12.0.4	0.110	0.573	69.0	27	15.5	104.9	8.9	60.1	27	11.9
11	119.4	0.136	0.709	84.7	28	19.9	99.5	14.1	70.6	28	15.5
12	120.0	0.157	0.819	98.3	29	23.8	96.2	19.5	78.8	29	19.9
13	119.0	0.170	0.886	105.4	.	25.7	93.3	22.8	82.6	.	23.8
	119.8	0.190	0.991	118.7		28.7	91.1	28.5	90.2	-	25.7

Repetition of Test of ½ H.P. Motor coupled direct

No. of Obs.	P.D. at Motor terms	Black	Amp.	Energy in Motor	Rev. of field r.p.m.	Drop in field	P.D. at armature	Energy in field	Energy in armature	Rev. of armature	Drop in armature
1	122.4	0.055	0.284	34.76	99.6	28.3	94.1	8.04	26.72	250	7.1
2	121.4	0.061	0.315	38.24	103.6	32.6	88.8	10.27	27.97	26	7.9
3	121.4	0.080	0.413	50.14	106	43.8	77.6	18.09	32.05	26.3	10.9
4	121.4	0.092	0.475	57.66	108.1	51.3	70.1	24.37	33.29	26.5	12.6
5	120.4	0.106	0.547	65.86	26.7	14.6	105.8	7.99	57.87	26.4	14.4
6	118.5	0.142	0.733	86.9	27.0	19.8	98.7	14.51	72.4	26.7	19.6
7	117.5	0.165	0.851	100.0	27.5	23.4	94.1	19.92	80.1	27.1	23.1
8	121.4	0.178	0.918	111.5	27.9	25.6	95.8	23.50	88.0	28.2	25.9
9	119.4	0.223	1.151	137.4	28.4	32.7	86.7	37.63	99.8	28.7	33.
10	118.5	0.254	1.311	155.3	28.4	37.2	81.3	48.77	106.5	28.7	37.6
11											
12											
13											



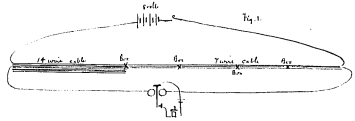
Test of 1/12th H.P. Crocker-Wheeler Fan Motor

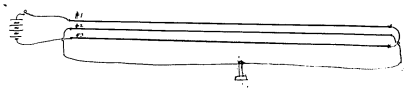
This motor was received from the Edison General Electric Co. of New-York store rooms. It is marked Type T # 3580 speed 1700 110 volts 0.75 amp.
Its weight is 19 3/4 lb. without fan or guard.
The resistances of the machine are:- One field magnet 47.2ω @ 15°C
The other " 52 "
In series 99.2ω
In parallel 24.7ω
Armature 25ω
Machine at slow speed 125w. wwww 142w
" " fast " 50w. 58w.

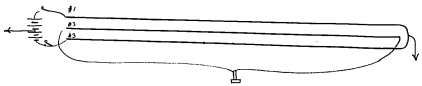
E.M.F.	Energy	Effort	Speed rpm	Speed fps	Balance	Moment	6165 × Moment	Delivering	Friction Eff.	Commercial eff.	Load
111.6	22.1	32	6000	100	–	–			32	–	Light Fast
105.1	0.7	17.5	4600	76.7	–	–			17.5	–	" Slow
92.4	1.7	24.1	3880	64.6	50 @ 6.5	325	2.003×10⁶	12.95	11.1	0.397	Slow 1 Fast
87.9	7.2	31.1	3400	23.3	50 @ 31.3	1565	9.647 "	22.5	8.6	0.335	Slow S.E.F.
73.0	8.5	30.4	1080	18.0	50 @ 43	2150	13.25 "	23.9	6.5	0.327	Slow 1 Fast
90.4 / 90.8	1.7	23.4 / 28.7	3200	53.3	50 @ 145	5225	32.36 "	17.25	16.35	0.539	Fast. S.E.F.
84.4 / 89.9	2.5	26.3 / 33.5	2165	36.1	50 @ 14	700	4.31.5 "	15.6	12.7 / 17.6	0.405	" "
110.2	3.5	38.8	3760	62.6	50 @ 20	1000	6.165 "	38.6	0.2		Slow "
96.6	5.5	44.3	2880	48.0	50 @ 25	1250	7.706 "	37.0	7.3	0.669	" "
99.4	8.9	51.2	2600	43.3	50 @ 32	1600	9.862 "	42.7	8.5	0.619	Fast "
79.6	14.1	56.5	2040	34.0	50 @ 0.5 / 100 @ 0.24	2220	13.87 "	47.2	9.3	0.557	" "
72.4	19.5	59.3	1740	29.0	50 @ 0.75 / 100 @ 0.25	2775	17.11 "	49.6	9.7	0.505	" "
67.6	22.8	59.8	1600	26.6	100 @ 0.26 / 100 @ 0.3	3300	20.34 "	54.2	5.6	0.514	" "
62.4	28.5	61.7	1420	23.8	100 @ 0.3 / 100 @ 0.3	3820	23.58 "	53.6	8.1	0.521	" "

To the 1/6th H.P. motor.

E.M.F.	Energy	Effort	Speed		Balance	Moment	6165 × Moment	Delivering	Friction Eff.	Commercial eff.	Load
57.1	2.02	24.7	2655	44.3	50 @ 16	550	3.391×10⁶	15.02	9.7	0.432	S.E.F.
50.6	2.58	25.39	2160	36.0	50 @ 23	900	5.550 "	19.98	5.4	0.523	1 F.P.
66.7	4.50	27.55	1744	29.1	50 @ 29	1150	7.090 "	20.63	6.9	0.411	2 F.L.P. 2 arm
57.5	5.98	27.31	1339	22.3	50 @ 33	1650	10.17 "	22.68	4.6	0.393	1 1
91.4	7.88	58.0	2925	48.8	50 @ 50	1250	7.706 "	36.07	13.9	0.544	2 D
79.1	14.4	58.0	2081	34.7	100 @ 0.25 / 50 @ 0.5	2300	14.18 "	49.20	8.8	0.566	1 4
71.0	19.7	60.4	1766	29.4	100 @ 0.3 / 50 @ 0.3	2900	17.88 "	52.56	7.4	0.526	1 2
70.0	23.8	64.2	1643	27.4	100 @ 0.3 / 50 @ 0.3	3350	20.66 "	56.60	7.6	0.505	1 3
86.4	38.	61.8	1181	19.7	200 @ 0.2 / 100 @ 0.3	4700	28.98 "	57.09	4.7	0.416	2 3
80.9	99.3	57.2	928	15.5	200 @ 0.3 / 100 @ 0.3	5450	33.61 "	52.09	5.1	0.335	3 4







The telephone just readily audible a current of 4 microamperes. This strength of current passing through the telephone, makes a click just audible when a short circuiting key round the terminals is operated

Experiments on induction between wires in cables

A series of experiments was carried out on the 25th May in the presence of Mr Adams, of the E.G.E.B., Dr Fuller, + Mr Taylor of the Pma. Co. Altoona, and of which the following are the particulars.

Two lead-covered cables were laid on the palings of the Laboratory and Phonograph Works, so as to enclose all the Buildings in one complete circle, commencing and terminating at the Galvanometer Room.

These were lead-covered cables. The first extended from the Galvanometer Room for 966 feet. This was a 7-pair cable of #18 B+S. guage (14 wire in all). The first 470' was saturated with paraffine, and the remaining 496' was unsaturated core (paper). The second cable continuing from this, was 2645' long, weighed 2619 lbs. or 0.99 lb. per foot, and contained 7 #14 B+S. jute-covered wires. The resistance of this length was 6.842 Ω @ 17° C. by Schenck and Tests and a capacity of 0.100 μ (one wire against all the other + sheath). This represents 13.5 Ω and 0.199 μ per mile. It is C.I. #192 and costs £0.399 or @ 60% off £0.156 per foot. The 7 wires were connected to 7 of the wires in the first cable, leaving 7 more vacant. The cable was suspended 6 feet from the ground on the paling, except at road crossings and at the end where 600 feet being in excess, it was laid back doubled for 300'. The cable was cross-bonded at 4 joint boxes.

The 7 wires brought with both end into the Galvanometer room had a total length of 3610 feet, and had a mean resistance of 13.3 Ω each, varying from 13.29 to 13.38 Ω. The insulation between the wires and between each to ground was practically perfect. The capacity of one wire to all the other and sheath was 0.135 μ. The wires were numbered to 1 to 7. A current was sent on each #1 of 0.5 amp. from 4 storage cells and a relay of 1.95 Ω resistance. Conducted to any other wire such as #3. Sending on the #1 produced disturbance on #3 relay, and worked a sounder. The relay is a polarized instrument not responding to a current of 6 milliamperes under the adjustment tried. When a telephone was substituted for the relay, the disturbance was loud. This telephone had a res. of 74.9 Ω and an inductance of 103 millihenries. The connections are shown in fig. 1.

The next experiment was the employment of a return-circuit and double opposite circuit. This reduced the inductive disturbance in the telephone nearly to zero.

Next, an artificial line was worked, (without the cable). It was made up of twelve condensers and resistances. Each resistance was 200 Ω of g.s. wire, and each condenser about 1.8 μ. The total capacity was 20.75 μ and total resistance 2375 Ω. Two relays in the circuit, one at each end. Next 10 more relays were inserted in the line at different distances making a total resistance of 5865 Ω. The twelve-relay line worked with the ordinary W.U. Relay at a speed of 30 words a minute. Steady current 0.020 amp.

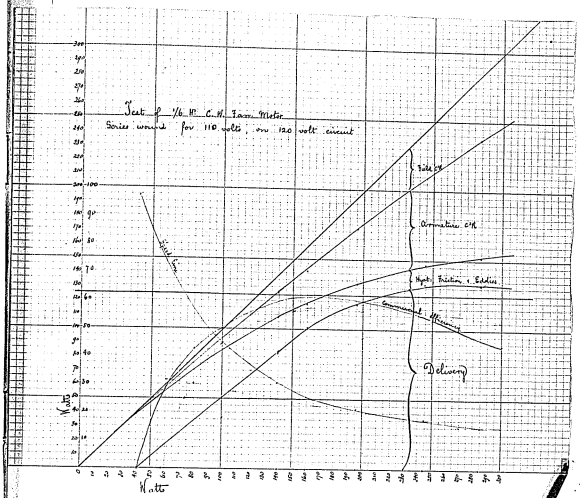
Finally, the artificial line was increased by 2355, and 16.265 μ making a total of 8220 Ω and 37 μ with 12 relays. This line worked at about 15 or 20 words per minute from one end to the other, corresponding to a cable 200 miles long.

Test of the 1/6th H.P. B.W. Fan Motor Marked

The weight of this motor is 27 3/4 lbs. It is series wound, and the armat

The motor was coupled to the Edison 500. watt 500. volt motor.

No. of test	P.D. at terms.	Ohmes	Amperes	Energy in Motor	Rev. of field	Drop in fields	P.D. at armature	Energy in field	Energy in armature	Rev. of armat.	Drop in armat.
1	117	0.067	0.346	40.5	7.1	2.5	114.5	0.754	39.6	12.56	4.35
2	120.	0.108	0.557	66.9	28.5	17.5	102.5	9.78	57.15	13.1	7.3
3	119.5	0.130	0.671	80.15	24.	21.7	97.5	14.6	65.55	13.5	9.1
4	120.5	0.163	0.841	101.3	30.3	26.	94.5	21.9	79.4	13.9	11.7
5	119.4	0.227	1.172	139.9	7.2	12.	107.4	14.1	125.8	12.75	14.9
6	119.	0.260	1.342	159.7	7.7	13.5	105.5	18.1	141.6	13.6	18.3
7	119.5	0.318	1.641	196.1	8.1	15.	104.5	24.6	171.5	14.4	23.6
8	119.5	0.397	2.049	244.9	8.4	17.5	102.	35.9	209.	14.8	30.3
9	120.	0.458	2.363	283.6	8.6	20.	100.	47.3	236.3	15.2	38.9
10	119	0.047	0.243	28.9	27.5	6.7	112.3	1.62	27.3	12.56	3.05



Type T # 6446, 1600 r.p.m. 1.75 amp. 110 volts.

(69)

with changes from field coils in parallel. Res. cool. Field in series 40.06 ohms 27.5
" " parallel 19.66 7.10
Armature 12.56

	Energy in watts	Effort	Speed r.p.m.	Speed r.p.s	Balance Zero = 0 = 7	Moment	6165 K Moment	Delivery	Friction Mech. + Elec.	Efficiency	Load
	1.5	38.1	5800	97	–	–	–	0	38.1	–	
	4.06	53.1	1990	33.2	50 to 34.3	2165	1.335×10⁷	44.32	8.8	0.662	High speed light
	6.08	59.5	1560	26.	100 to 20 20 to 6	2750	1.696	44.09	15.4	0.550	1 amp. 1/2 1/4
	9.83	69.6	1310	21.8	100 to 25 25 to 23	4100	2.525	55.10	14.5	0.644	1 –
	17.5	108.3	1810	30.2	100 to 25 25 to 23	4700	2.898	87.5	20.8	0.626	1 –
	24.5	117.1	1540	25.7	200 to 50 50 to 37	6350	3.915	108.6	16.5	0.620	1 1/4
	38.8	132.7	1290	21.5	200 to 50 50 to 25 25 to 20	8850	5.457	117.3	15.4	0.598	1 1/3
	62.1	146.9	1060	17.7	200 to 50 50 to 30	12,150	7.490	132.6	14.3	0.541	2 1/3
	84.9	151.4	900	15	200 to 50 50 to 37	14,300	8.816	132.2	19.2	0.466	2 1/2
2	0.84	25.6	3800	63.3	–	–	–	0	26.6	–	Low speed unmeasured

Motor Driving 15 3/4" fans

Slow Speed 1370 r.p.m. Watts 0.170 amp 0.877 P.D. 119 volt 104.3 watts
High " 1700 " " 0.259 " 1.336 " 117.5 " 157 watts

When fitted with 12" fans blades regular Edison General type

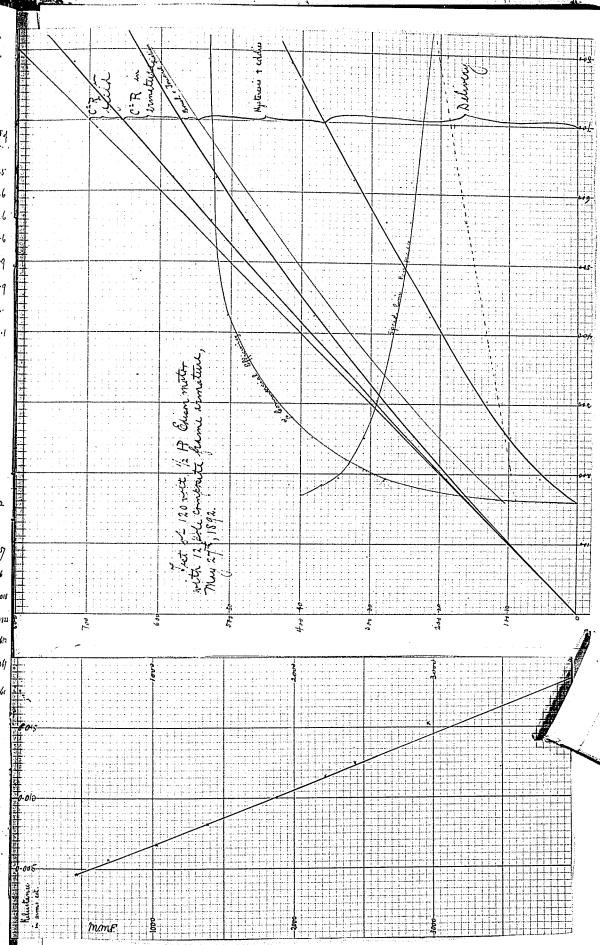
Slow speed 1720 r.p.m. " 0.125 " 0.645 121 " 78.0
High " 2130 " " 0.190 " 0.980 " 118.6

Res. of motor @ 44°C on arm. (hot) 3.77 Ω — 1.39 2.38
" " @ 15°C " " 3.47 Ω field 1.28 Ω = 2.19 Ω

No. of Obs.	P.D. at motor terms	Amps.	Amp.	Energy absorbed by motor	Res. of field	Drop in field	Energy in field	Energy taken by armature	Resistance of arm.	P.D. at arm. terms	Drop in arm.	EMF of arm.
1	122	0.255	1.215	160.4	1.28	1.6	1.2	158.2	2.19	120.4	2.9	117.5
2	118.9	0.317	1.636	194.2	1.29	2.11	4.1	190.1	2.20	116.2	3.6	112.6
3	120.	0.410	2.116	253.9	1.30	2.75	5.8	248.1	"	117.3	4.7	112.6
4	119.5	0.493	2.545	304.1	1.31	3.33	8.5	295.6	"	116.2	5.6	110.6
5	121.5	0.678	3.500	425.2	1.33	4.65	16.3	408.9	2.25	116.8	7.9	108.9
6	119.	0.910	4.696	558.8	1.35	6.34	29.8	529.0	2.30	112.7	10.8	101.9
7	121.	0.990	5.110	618.2	1.37	7.0	35.8	582.4	2.34	114.	12.0	102.
8	118.5	1.280	6.605	782.6	1.39	9.2	60.6	722.0	2.38	109.3	15.2	94.1
9												

Test of 120 volt motor for speed and Reluctance
With 12 poles in the armature, and 0.020" (0.05 cm) endplay.

No. of Obs.	P.D. at Armature	Current in field Amps.	Amp.	Drop in Armature	EMF of arm.	Speed Rpm	Rps.	EMF per rev. per sec.	F.	B	R
1	118.5	0.83	4.28	2.97	2.5	116.	1690	28.2	4.11	194,600	.002
2	119.5	1.14	5.88	4.65	2.4	116.1	1630	27.2	4.27	202,200	.0211
3	119.6	0.612	3.52	2.436	2.3	117.3	1720	28.7	4.09	192,700	.0227
4	120.	0.620	3.20	2.212	2.3	117.7	1750	29.2	4.03	190,800	.0104
5	120.5	0.526	2.71	1.874	2.3	118.2	1825	30.4	3.89	184,200	.0112
6	121.	0.392	2.02	1.397	2.3	118.7	1988	33.1	3.59	170,000	.0207
7	121	0.292	1.51	1.044	2.4	119.6	2200	36.7	3.23	153,000	.0219
8	120	0.196	1.01	698	3.0	117.	2700	45.	2.60	123,100	.0146
9	117	0.127	0.655	453	5.2	111.8	3220	53.7	2.08	98,480	



Test of Edison Composite Frame Armature ½ H.P. Motor.

The previous test of this motor is given on page 58. Since that time the number of segments has been increased from 6 to 12. The same winding however has been applied, as in the last armature. The motor was floated in the tank, and coupled to the other 500-volt motor

Time	Speed of motor rps	Volts across terminals	C.P.R. in armature	Effort	Balance	Moment	6.16 × Moment	Damping	Friction	Efficiency Commercial	Load
[illegible]	40	2.938	3.4	154.4		–	–	–	154.4	0	light [illegible]
[illegible]	34.5	3.263	5.89	184.2	100 in 30 / 50 in 15	2550	1.572×10⁴	54.2	130.	0.279	coupled
[illegible]	31.	3.63	9.9	238.2	200 in 80 / 0.49	5100	3.145.	97.5	140.7	0.384	1½ SEF
[illegible]	29.2	3.787	14.3	281.3	700 in 90 / 1.4	7350	4.532.	132.3	149.0	0.435	2 ½ ..
[illegible]	26.7	4.08	27.6	381.3	[illegible]	13,050	8.045.	214.8	166.5	0.505	2½ full
[illegible]	24.3	4.492	50.7	478.3	[illegible]	18650	11.50 .	279.4	198.9	0.500	2 . 8 .
[illegible]	22.2	4.215	61.3.	521.1	[illegible]	21,850	13.47 .	325.9	195.2	0.527	2 . 6 .
[illegible]	21.7	4.336	100.0	622.0	[illegible]	31,100	19.18 .	416.2	205.8	0.532	4 . 9 .

log 14·69 = 1·167021 8
2·104 = 0·3230457
0·8439761 — 6·98194
1·6050999
0·0485562 — 8·88968

log 102·21 = 2·009+9359
99·95 = 1·9997828
0·0097109 — 1·022611

log 0·2104 = 7·3230457
0·009 7106 — 2·05743
7·3133351 — 0·205748

log 0·205748 7·3133351
·304797 4840107
7973478
·64516 8096674 — 9·72006
1876784 — 9·72027

143652 1573112
0048203 — 1·42059
1524909 — 1·42066

1·61594 2084250
0048203 — 1·59706
2036047 — 1·5981

log 106·3 = 2·0265336
104·83 = 2·0204859
0·0060476 7 — 1·014023

log 205748 3133351
0060477
3072874 — 0·0202903

· 972027 9876784
0060477
9816307 — 9·58585

· 0·9866 9941411
143652 1573112
1514533 — 1·41729
1·41727

· 1·61594 2084250
9941411
2025661 — 1·59428

log π = 0·4971499
+ = 0·6020600
1·8950899

log 14·69 1·1670218
0·0097106
7·1573312 = 0·143652
0·1436534

2·3133351
1·8950899
3·5182452
0·2084250 = 1·61594
1·61594

log 106 = 2·0253058 7
104·83 = 2·0204859
0·0048202 8 — 1·011161

205748 3133351
0048203
3085148 — 2·03459
2·03477

9·72027 9876784
0048203
9828671 — 9·6122
9·61319

143652 1573112
0060477
1·7132635 — 1·41665

1·61594 2084250
0060477
2023773 — 1·59425
1·59359

1·0
0·0060476 7
0·9939523 3 — 0·98571

205748 3133351
9941411
3074762 — 202986
0·0202991

9·72027 9876784
9941411
9818195 — 9·5998
9·59002

These numbers are those independently computed by Mr G. A. Hamilton.

On the Matthiessen Standard of Conductivity

(7)

The resistance given by Matthiessen for a hard drawn copper wire one metre long and weighing one gramme is 0·1469 B.A.U. @ 0°C.
Also the resistance of a hard drawn copper wire 1 metre long and one millimetre in diameter is 0·02104 B.A.U. at 0°C.
From this the "metre-millimetre" wire weighed $\frac{14{\cdot}69}{2{\cdot}104} = 6{\cdot}98194$ gms.
And its specific gravity $= \frac{6{\cdot}98194}{0{\cdot}7854} = 8{\cdot}88968$.
The relative conductivities he gives for hard and soft copper are 99·95 and 102·21. A ratio of 1·022611.

The resistance of the soft copper metre gramme @ 0°C is		0·143652 B.A.U.
" " " " " metre millimetre @ 0°C		0·0205748 . . .
" " " " " cubic centimetre @ 0°C		1·61594 × 10⁴ . .
" " " " " mil foot @ 0°C		9·72027 . . .

The factor of conversion from the B.A. to Legal ohm is 1/1·011161
From this the metre gramme @ 0°C is 0·142066 Legal ohms.

" " " metre millimetre	0·203477	" "
" " " cubic centimetre	1·5991 × 10⁴	" "
" " " mil foot	9·6132	" "

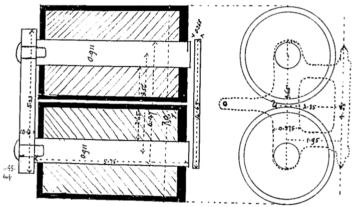
The factor of conversion from the B.A. to New Standard ohm is 1/1·014023
From this the metre gramme @ 0°C is 0·141665 New ohms

" " " millimetre	0·0202903	" "
" " " cubic centimetre	1·59359 × 10⁻⁶	" "
" " " mil foot	9·5859	" "

If however the factor from the B.A. to New Standard is 0·9866
The value of the metre-gramme @ 0°C is 0·141727 New ohms.

" " " metre-millimetre	0·020299	" "
" " " cubic centimetre	1·59428 × 10⁻⁶	" "
" " " mil foot	9·59002	" "

Section of W.U. Relay through core centers.



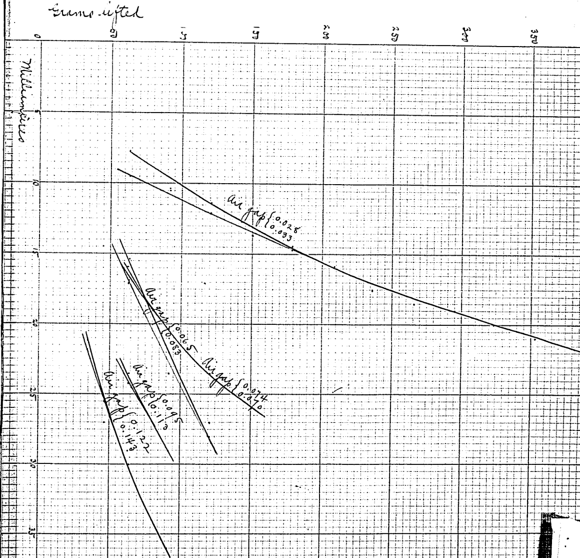
Weight of magnet	420 gms.	
" " armature	16.7	
Moment of Inertia of the armature about its axis }	[illegible] cm²gms.	
Cross section of cores	0.652 cms²	
" " armature	0.261 "	at narrowest part. 0.0405 sq. ins.
" " yoke	0.888 "	
Radius of retractive forces on hook	2.35 cms.	
Mean rad. of attractive forces	1.95 "	
Radius of contact point	4.28 "	
Resistance @ 15°C.	139 ω. (two coils in series)	
Virtual rad. of armature / Radius of gyration }	2.840 cms.	

Winding: 28 layers 3430 turns on [illegible] spool. 30 layers 4070 turns on other

Wire: #29 B&S. 0.0113" d.s.c. to 0.0135"

Total. 58 layers 7500 turns

This relay rewound on the 22nd June over the same cores, but on a hard rubber shell with # 27 B.W.G. / 26 B&S. wire 0.0159" s.c. to 0.018" Total 52 layers 5720 turns 2860 turns on each spool (26 layers of 110 turns each).
Res. of relay 53.52ω @ 30°c.



Measurements with a Western Union Relay.

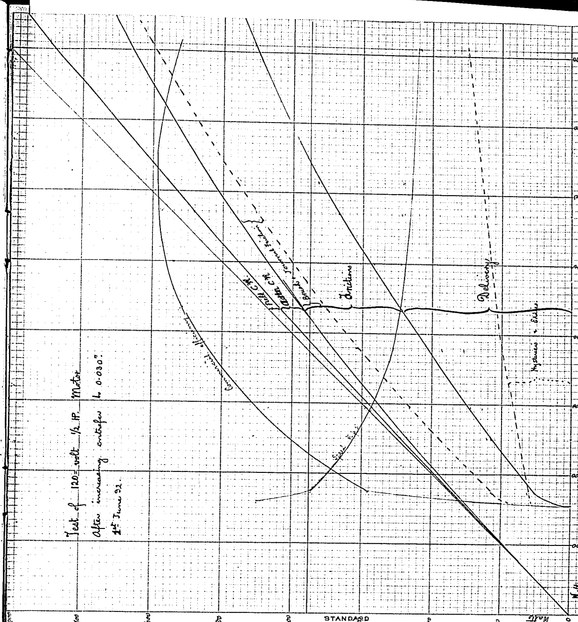
The attractive force exerted by a standard Western Union Relay was measured by setting the relay on a vertical board, with its armature in the horizontal plane, and attaching a bucket to the hook so as to make in place of the spring, a definite load. The pull obtained for different current strengths in the coils was thus determined. The corresponding distance between pole and armature – the entefer – was measured with a steel wedge. It was never quite equal on both sides, so the wedge was used at each pole. The entefer was observed with the current off, and the relay had to lift the armature up from this distance.

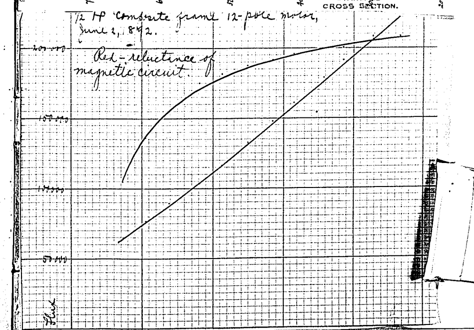
Entefer	Total Wt Lifted	Single direction Current			Current Flow in ret.	Single direction Current						
		Flow in ret.	Current MMF.				MMF.					
0.065 / 0.063 } 0.064	63	590	0.0153		440	0.0171						
	92	380	0.022		320	0.0235						
	121	270	0.028		280	0.0270						
0.025 / 0.033 } 0.029	63	1800	0.0077		820	0.0095						
	92	710	0.0103		700	0.0105						
	121	650	0.0113		610	0.0121						
	150	540	0.0137		540	0.0137						
	179	510	0.0144		500	0.0147						
	208	470	0.0158		470	0.0158						
	237	420	0.0175		420	0.0175						
	266	400	0.0185		400	0.0185						
	295	385	0.019		385	0.019						
	324	364	0.020		364	0.020						
	353	349	0.021		349	0.021						
	382	218	0.0217		218	0.0217						
0.095 / 0.113 } 0.104	63	286	0.0235		211	0.0262						
	92	173	0.029		173	0.029						
0.122 / 0.143 } 0.132	63	305	0.029		297	0.030						
	46	325	0.027		325	0.027						
	34	415	0.0212		405	0.0218						
	92	250	0.036		250	0.036						
0.074 / 0.070 } 0.072	63	441	0.0158		511	0.0169						
	92	435	0.0203		435	0.0203						
	121	375	0.0235		375	0.0235						
	150	339	0.0256		339	0.0256						

Time	Volts at motor terms	Obach	Amp.	Energy absorbed by motor	Res. of field	Drop in field	C²R loss of Energy in field	Energy entering arm:	Resistance of arm:	P.D at arm terms	Drop in arm.	EMF
12.00	125.5	0.242	1.249	156.8	1.28	1.6	2.0	154.8	2.19	123.9	2.7	121.2
14.30	119.4	0.282	1.455	173.1	-	1.9	2.7	170.4	2.19	117.1	3.2	113.9
14.35	119.	0.409	2.111	251.2	1.30	2.7	5.8	245.4	2.23	116.3	4.7	111.6
14.40	119	0.480	2.477	294.8	.32	3.3	8.1	286.7	2.26	115.7	5.6	110.1
14.43	119.	0.615	3.174	377.7	.34	4.3	13.5	364.2	2.30	114.7	7.3	107.4
14.47	119.5	0.705	3.638	434.7	.36	4.9	18.0	416.7	2.33	114.6	8.5	106.1
14.51	121.	0.800	4.128	499.5	.38	5.7	23.5	476.	2.36	115.3	9.7	105.6
14.55	121.	0.915	4.722	571.4	.40	6.6	31.2	540.2	2.39	114.4	11.3	103.1
15.00	120	0.995	5.135	616.1	.42	7.3	37.4	578.7	2.42	112.7	12.4	100.3
15.05	121	1.310	6.758	810.8	1.44	9.7	65.8	745.	2.46	111.3	16.6	94.7

The following speed observations were also made:–

No. of Ob.	Obach in Field	Current in Field	M.M.F.	Stde. Galv. in arm. cct.	Amp. Volts in arm	Drop in arm:	EMF of arm:	EMF per rev. per sec:	Revs. per min	Revs. per sec:	F	B	R
1	1.310	6.760	4674	50°	0.899 122	2.0	120	4.40	1640	27.3	2.082 × 10⁵		22.44 × 10⁻³
2	1.20	6.192	4281	49°30'	0.883 119	1.9	118.1	4.39	1612	26.9	2.078.		20.60.
3	1.08	5.573	3853	49°	0.867 119	1.9	118.1	4.25	1665	27.8	2.013.		19.14.
4	1.00	5.160	3568	49°	0.867 119	1.9	118.1	4.22	1680	28.0	1.999.		17.85.
5	0.883	4.557	3151	48°30'	0.852 119	1.9	118.1	4.14	1710	28.5	1.960.		16.08.
6	0.798	4.118	2847	49.	0.867 118.5	1.9	116.6	4.06	1720	28.7	1.923.		14.81.
7	0.700	3.613	2498	48.	0.838 119.5	1.8	116.7	3.96	1770	29.5	1.875.		13.33.
8	0.595	3.071	2123	49.	0.867 119.5	1.9	116.6	3.85	1820	30.3	1.823.		11.65.
9	0.508	2.622	1813	49°30	0.883 119.5	1.9	116.6	3.69	1895	31.6	1.747.		10.38.
10	0.389	2.008	1388	51°	0.931 119.5	2.0	116.5	3.28	2130	35.5	1.553.		8.93.
11	0.295	1.522	1052	53°15	1.01 118	2.2	115.8	2.90	2400	40.0	1.373.		7.66.
12	0.200	1.032	713	61°	1.360 114	3.0	111.0	2.32	2870	47.8	1.099.		6.49.

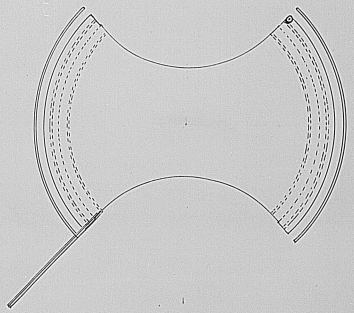


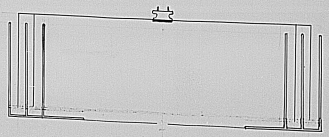


Tests of 12-poled armature ½ HP. Composite Frame Motor 1st June after grinding surface of armature to as to make the entrefer 0.030".

The motor was bolted by the flexible rod to the 500-volt ½ HP. motor and the following results obtained.

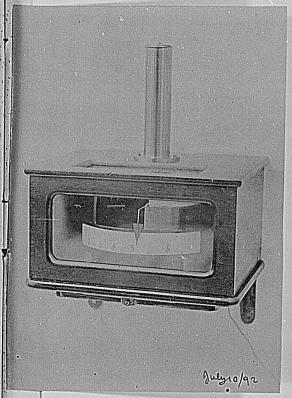
Field Amps	Volts per turn per bar	E.M.F. in armr.	Effort	Belt pull		Moment	Belt × Moment	Delivery	Friction	Commutator efficiency	Load	
				lb.	oz.							
1.95	2.69	3.4	151.4	—	—	—	—	0	151.4	0	Light	
2.35	3.06	4.6	165.9	200 / 200	0 / 8	22.00	1.357 × 10⁷	50.5	95.3	0.292	Bolted	
2.83	3.45	10.4	235	500 / 400	0 / 15	57.50	3.595	114.5	120.5	0.456	1/2 HP	Arm.
2.95	3.73	13.9	272.8	800 / 600	0 / 7	70.00	4.397	128.2	144.6	0.435	2	"
2.98	4.16	23.1	341.1	500 / 800 / 300	0 / 15 / 0 / 20	117.50	7.244	186.9	154.2	0.495	2	6
2.95	4.29	30.8	385.9	1100 / 1000	0 / 17 / 15	159.50	9.832	243.4	142.5	0.560	2	3
2.97	4.27	40.2	435.8	1500 / 900	0 / 13.5 / 15	187.50	11.52	284.5	151.3	0.570	2	5
2.95	4.21	53.4	556.8	1700 / 1500 / 1000	0 / 5 / 0 / 20	225.00	13.72	336.1	150.7	0.588	2	Light
2.9	4.11	64.0	514.	2000 / 1900	0 / 14 / 0 / 25	247.00	14.98	368.5	148.5	0.593	2	Bolted
2.97	4.36	112.6	602.4	3000 / 2900 / 1000	0 / 3 / 0 / 20 / 0 / 25	347.50	21.06	457.0	175.4	0.564	5	1/2 HP



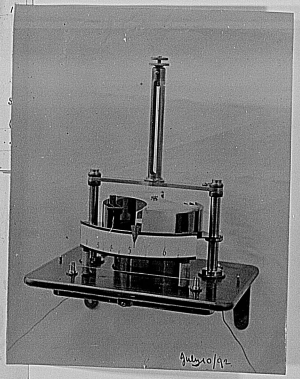


The torsional moment of the suspension at 90° twist =

$$M = \frac{28.5 \times 6.51 \times 0.183 \times 0.183}{13.1} = 7.144 \times 10 \text{ cm dyne}$$



July 10/92



July 10/92

Fig. 1
Obr.
20m
40m
20m
40m
945
964
971
975
990
1030
1037
1039
1054

Trial Scale of the 600 volt Static Voltmeter June 3rd 92

The distance between the suspension wire (0.002" P.S.E) is 0.361 above and 0.39 below. The length of the wire is 13.1 Freems. The Mass of the whole suspension is 28.5 grs (1844). The distance between channel is .0.52. The angle subtended by the channel is . The thickness of the vanes is 0.039. The following observations were made of the scale indications.

1.15	3.40 [illegible]	3.57 [illegible]	3.70 [illegible]	4.02 [illegible]	4.20 [illegible]	4.55 [illegible]	4.90 [illegible]	5.35 [illegible]	5.90 [illegible]	6.3 [illegible]	6.58 [illegible]
0	323.3	345.2	364.1	391.2	415.1	440.2	462.1	490.3	519.2	553.0	599.0
0	63.3	67.6	71.3	76.6	81.3	86.2	90.5	96.0	101.7	108.3	117.3

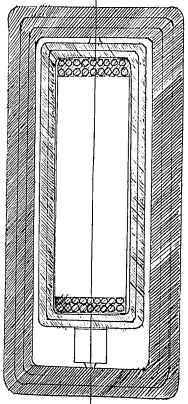
Res. of Vector 2074 ω. Res. of cct 10,592 Ratio 5.107

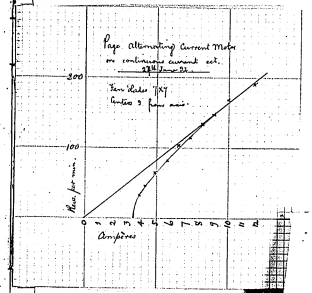
Test made for Efficacy of Edison Transformer Patent June 3rd 92

Continued from p. 62

The storage cells used in the first trial were doubled in capacity by using another pair of the same size of lead plate in each jar. These were "formed" in the same manner as the others. The following observations were made of the transformation with the commutator running.

Time	Time after charging cells in series	Mean Amp	Apparent Watts absorbed by cells	Watts at secondary terminals	Ohmic in circuit cell	Amp Mean	Apparent efficiency of cells	Eff. efficiency				
12.2.	3'.10'	0.416	50.7	19.5	0.147	0.758	14.8	0.242				
12.2	3'.20'	0.439	53.6	16.7	0.275	1.42	23.7	0.442				
12.4.	4'.20'	0.571	70.8	19.1	0.285	1.06	20.2	0.286				
12.5.	4'.16'	0.549	68.6	20.0	0.207	1.07	21.4	0.312				
12.3	4'.40'	0.615	75.6	18.3	0.287	1.07	19.6	0.259				
12.2.	5'.0'.5 44"	0.725	88.8	14.7	0.418	2.16	31.75	0.361				




Page Alternating Current Motor
on continuous current ckt.
Ten Volts
Curve 3 from max.
300
100
Amperes
0 1 2 3 4 5 6 7 8 9 10 11 12

Design for an alternating current motor meter in the Edison patent case.

The size of wire forming the inner coil is #13 B.W.G. 0.095" s.c.c. to 0.103". Nine turns wide and two layers make 18 turns in each of the movable coils. Each turn will be 1 foot, so that the length in each coil will be 18' @ 0.001144 = 0.02 ω. The outer coil will be composed of #12 B.W.G. 0.109" s.c.c. to 0.120". There will be 3 layers and 12 turns to each or 36 turns. Each turn = 1.5' so that there will be 54' of wire, @ 0.0008688 ω = 0.047 ω. The total resistance being 0.067 ω @ 20° C. and the total drop at 10 amp. 0.67 volts in ω.

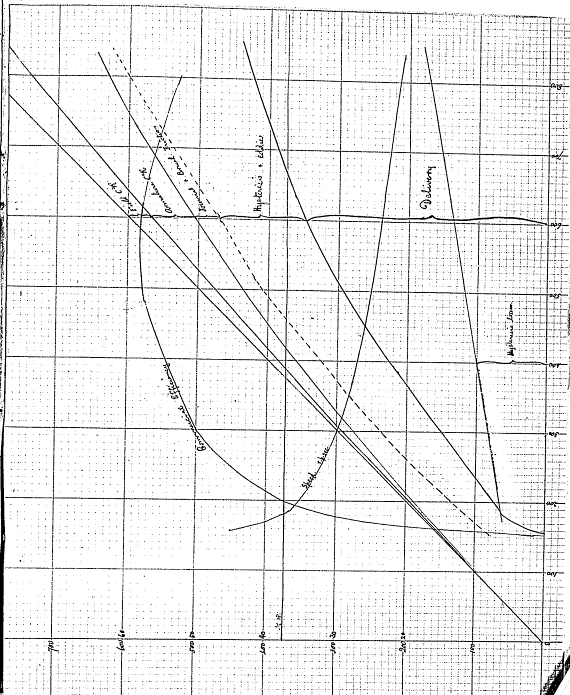
The weight of the two movable interior coils is 36 × 0.02735 = 0.9847 lb.

The instrument, as first tried, had too small a pull, and gave trouble at the commutator owing to the existence of two separate circuits. By employing #17 B.W.G. 0.058" s.c.c. to 0.066", each of the four inner coils can be formed of 3 layers in 9 turns, or 27 turns. The resistance of the 27' = 0.083 ω. In all 108' and 0.083 ω. The total resistance will be 0.13 ω. The width of each coil will be 9 × 0.066 = 0.594" and the thickness 3 × 0.066 = 0.198".

On completion, the resistance of the instrument was 0.1285 ω @ 25° C. It was tried on 120 volt continuous current circuit with following results

No. of Obs.	Current in cct.	Ohmch.	Amp.	Time	Revs.	Rpm.	Rpm per amp	Rpm
1	8	0.605	3.35	60 sec.	Just stops			-
2	9	0.720	3.716		33	0.55	8.882	-
3	10	0.812	4.190		45.7	0.762	10.910	-
4	12	0.955	4.929		65	1.083	13.19	-
5	14	1.106	5.707		81	1.35	14.19	-
6	16	1.260	6.502		103	1.72	15.84	-
7	18	1.418	7.316		115	1.92	15.72	-
8	20	1.584	8.174		134	2.23	16.39	-
9	22	1.746	9.008		148	2.47	16.43	-
10	25	1.940	10.01		168	2.8	16.78	-
11	30	2.286	11.80		190	3.17	16.10	-

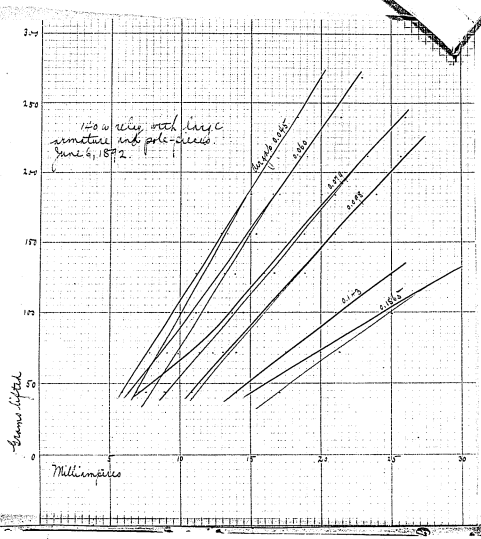
Time	Volts at motor terms	Obach	Amp.	Energy absorbed by motor	Res: of field	Drop in field	C²R loss of energy in field	Energy entering armature	Res: of arm:	P.D. at armature terms.	Drop in arm.	EMF.
	125.5	0.242	1.249	156.8	1.28	1.6	2.0	154.8	2.42	123.9	2.7	121.2
12.00	119.4	0.300	1.548	184.8	1.34	2.1	3.21	181.6	2.42	117.3	3.7	113.6
.15	119.4	0.378	1.951	232.9	1.36	2.7	5.18	227.7	2.45	116.7	4.8	111.9
.18	119.0	0.485	2.503	297.8	1.38	3.5	8.65	289.1	2.48	115.5	6.2	109.3
.24	119.4	0.708	3.653	436.2	1.39	5.1	18.55	417.6	2.50	114.3	9.1	105.2
.30	119.4	0.975	5.031	600.7	1.40	7.0	35.4	565.3	2.52	112.4	12.7	99.7
.34	120.5	1.170	6.036	727.2	1.41	8.5	51.4	675.8	2.54	112.0	15.3	96.7
.38	120.5	1.340	6.914	833.0	1.42	9.8	67.9	765.1	2.56	110.7	17.7	93.0



Test of ½ H.P. Edison Composite Frame Motor.

The only change made since the last test has been the insertion of platinoid wire 0.018" in diam: between the commutator and the armature. This wire has a resistance of 0.73 ω per foot and there are 0.2' in each. The resistance of this length is 0.15ω and the resistance of each section in the armature is 0.367ω so that each local circuit has been increased from 0.367ω to 0.667ω or in ratio of 1.818. This wire in the open air carries 8.3 amp. with visible luminosity — red hot. It burns away at 11.6 amp.

Speed r.p.s.	Volts per 100 revs per sec	C²R in amps	Effort	Balance	Moment	6165 × Moment	Delivery	Friction	Commercial efficiency	Load
45	2.69	3.4	151.4	- -	-	-	-	151.4	0	
1200 24.7	3.10	5.80	175.8	50 0 -14 200 0 15"	2800	1.726×10⁷	63.3	112.5	0.3143	Unloaded
1980 32.0	3.39	9.32	218.4	50 0 15" 200 0 60	4750	2.929	96.7	121.7	0.4415	S.E.F. 12
1800 30.	3.64	15.5	273.6	200 0 35" 50 0 8	7900	4.871	146.1	127.5	0.490	" 31
1610 36.8	3.92	33.4	384.2	100 0 15	15000	9.248	247.8	136.4	0.568	Loaded
1460 24.0	4.15	63.8	501.5	400 0 -12.5 100 0 34	23375	14.41	311.5.8	155.7	0.576	"
1340 22.3	4.34	92.5	583.3	1000 0 34 200 0 12 50 0 -5	28750	17.73	395.3	188.0	0.544	"
1250 20.8	4.47	122.4	642.7	1000 0 34 500 0 34 50 0 -14	33800	20.84	443.4	209.3	0.520	" 5½


Dynamometer
Millimpères
0
5
10
15
20
25
30
50
100
150
200
250
300
Dynamo 0.055
0.060
0.078
0.098
0.129
0.165
Iron wire with large armature and pole-pieces
June 4, 1872.

Test of W.U. neutral Relay after exchanging the Armature.

Two pole faces of annealed wrought iron were screwed on to the relay cores, and the armature was made of a sheet of annealed wrought iron 0.107 thick. The winding, and all the arrangements were left unaltered. The test was made as on p. 73.

Distance	Total Wt lifted	Single direction of current: Current	Single direction of current: MMF	Single direction of current: Reluctance	Both directions of current: Current	Both directions of current: MMF	Both directions of current: Reluctance
0.193	43.5	0.0151			0.0171		
0.150	71.5	0.020			0.0213		
0.165	99.6	0.025			0.0250		
	127.6	0.029			0.0290		
0.145	127.6	0.025			0.025		
0.141	99.6	0.0211			0.0211		
0.143	71.5	0.0175			0.0175		
	43.5	0.014			0.014		
0.098	43.5	0.0108			0.0105		
	71.5	0.0131			0.0140		
	99.6	0.0160			0.0166		
	127.6	0.0185			0.0188		
	155.7	0.021			0.021		
	183.7	0.0239			0.0239		
	211.7	0.0257			0.0257		
0.079	239.8	0.0233			0.0233		
	211.7	0.0260			0.0260		
	183.7	0.020			0.021		
	155.7	0.0188			0.0188		
	127.6	0.016			0.0167		
	99.6	0.0137			0.0145		
	71.5	0.0114			0.0123		
	43.5	0.0071			0.0089		
0.060	43.5	0.0064			0.0077		
	71.5	0.0091			0.0099		
	91.6	0.0112			0.0120		
	127.6	0.0132			0.0139		
	155.7	0.0149			0.0162		
	183.7	0.0166			0.0171		
	211.7	0.0185			0.0191		
	239.8	0.0214			0.0214		
	267.9	0.0229			0.0229		
0.045	267.9	0.020			0.020		
	239.8	0.0183			0.0183		
	211.7	0.0164			0.0164		
	183.7	0.0150			0.0150		
	155.7	0.0128			0.0133		
	127.6	0.0112			0.0117		
	99.6	0.010			0.0103		
	71.5	0.0078			0.0085		
	43.5	0.0059			0.0069		

The new armature makes 210 complete vibrations per min = 3.5 per sec.

$l = \frac{\cancel{6.40} \times 981}{(3.5)^2} = 2800$. The mass of the armature is 18.4 gms

The moment of inertia is 73.6 cm²gms.

Test of 1000 volt static voltmeter June 7th 92.

The following scale was measured for the 1000-volt meter.

Outline of Specifications proposed for the Philadelphia Telegraph Line. June 10th 92.

The size of copper wire #14 B.&S. 0.0641" covered to 0.1891" with paper in three coats if possible. The first coat japanned, the others soaked in paraffin wax. 14 wires laryed up in one cable.

Weight of wire per foot 0.01245 lbs. per mile 66.74 lbs.
" 14 wire - ~~foot~~ 66.1743 lbs, - - 934.3 "

Cost of copper in cable per foot @ $0.16 = $0.02759 per mile $149.50

Resistance of wire per foot = 0.002513 ω per mile 13.27 ω @ 30°C or 13.60 ω

Estimated capacity of one wire to ground 0.2 μ per mile.

Capacity × Resistance for one mile = 2.736
" " " 100 miles = 273.60.

Approximate internal diameter 0.85"
" external " 1.02" } Thickness of lead 0.075".

Measurement of the Power needed to operate electrically the Aeolian organ in Mr Edison's house. 8th June.

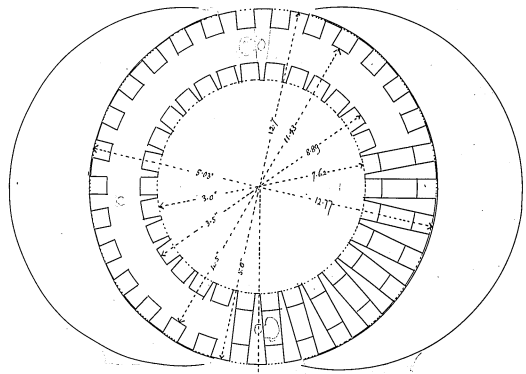
Current supplied to 1/8 H.P. Perret motor 0.925 amp. varying 0.1
Pressure " " " " " " 115 volts
Energy " " " " " " 106 watts

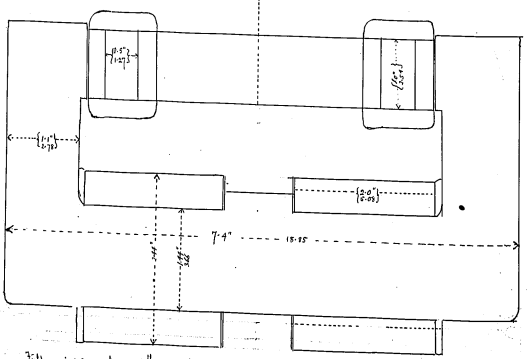
The motor does most work when all the stops are in and the music is not played.
106 watts absorbed by this motor represent 45 to 50 watts delivered, according to our tests of this style of motor.

Resistance and Inductance of a Phonoplex Receiver 8th June.

Res: 99.14 ω. @ 17° C.
Inductance with cover diaphram removed 45.6 mh.
" " cover hard down on poles 116.5 mh.

Torque per ampere = $\frac{100{,}000 \times 270 \times 0.1}{6.28}$ = 429,700 dyne cms = 438 gm-cms.
= 0.966 lb. cms = 0.380 lb-inches

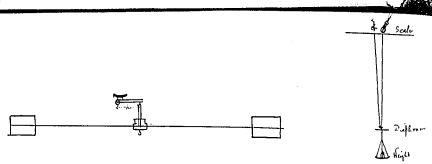


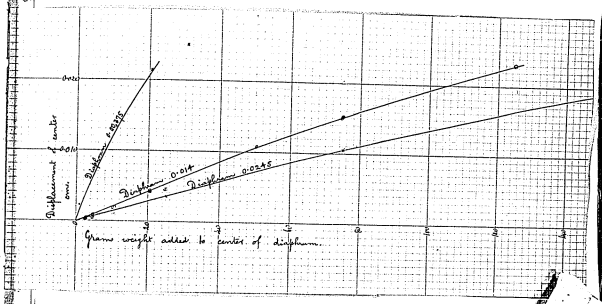


Field winding altered 7th June to go turns of #13 B.W.G. on each spool + spools in multiple
Section of field magnet altered to 13.15 sq/cms.

Design for a Phonograph Motor. Battery type.

Type	Bipolar, series field, gramme ring armature with teeth.			
Speed	400 r.p.m. 6.6 r.p.sec.			
E.M.F.	1.85 volts.			
Battery	4 Edison = Lalande cells each 0.6 volt 0.03 w.			
Driving EMF	2.65 volts			
Current	3 amp			
Drop in battery	0.36 volt			
P.D. at battery terminal	2.29			
Drop in leads	0.14	0.047 w.		
P.D. at machine terminal	2.15			
Drop in motor	0.30	0.10 w. res.		
External Diameter of armature	5"	12.7 cms.	Circumference	15.71" 39.89 cms
Groove diameter " "	4.5"	11.43 -		14.14" 35.91 -
Mean " " "	4.0"	10.16 -		12.57" 31.92 -
Internal groove " "	3.5"	8.89 -		11.0" 27.93 -
Internal " "	3.0"	7.62 -		9.426" 23.94 -
Depth of teeth	0.25"	0.635.		
Breadth of armature	1.0"	2.54 -		
Cross section	1.0 × 0.5 (2.54 × 1.27)	= 0.5 sq/in	3.225 sq/cms.	
Breadth of each groove	0.265"	0.673 cm.		
Breadth of each tooth	0.259"	0.658 cm. at outer and 0.049" 0.124 m. at inner circumference		
Ext. Surface of each tooth	0.259 sq/in.	1.671 sq/cm.		
Tot Winding space section per groove	0.265 × 0.25"	= 0.06625 sq/in	= 0.673 × 0.635 = 0.4274. sq/cm.	
Area of iron surface	8.592 sq/in	55.43 sq/cms.		
Volume of iron in armature	8.592 c. in.	140.8 c.c.		
Sp. g. assumed	7.8			
Mass of iron	1098 gms	2.421 lbs.		
Peripheral speed of arm	524' per min,	266 kms		
Thickness of body wall mica	0.010"	0.025 cm.		
Diameter of wire	0.072"	#15 B.W.G. s.c.c. to 0.080"		
Length of mean turn	0.5'			
Total length on arm	90'			
Total number of turns	270			
Number of turns in each gp	9,	three layers of 3 turns each.		
Total weight of wire on arm	1.5 lbs.			
Resistance of winding	0.045 w @ 20°c.	0.0512 w @ 60°c		
Total Flux in arm	402,800			
B - -	15,930			
Pole surface on teeth	12 × (1.671 + 0.33)	= 24 sq/cms.	B = 4,300	
Clearance + entrefer	0.025"	0.078 cm.		
Reluctance of gaps	$\frac{2 \times 0.078}{24}$	= 0.0032	= 3.2 mil	
Total estimated rel.	0.005			
Length of path in arm	4.5"	18 cms. section 6.45 × 3 cms × 0.0025.	0.0065	
MMF required	511			
Exciting power	422.			
Turns	127	64 turns on each spool		
Field winding	4 layers of 16 turns each on spools		# 12 B.W.G. 0.109" s.c.c. 0.120	
Depth of winding	0.49"	over insulation 0.50"		
Length of coil	16 × 0.12 = 1.92"	say 2.0"		
Diameter of core	1.44"	3.66 cms.		
Cross sectional area	1.629 sq/in	10.51 sq/cms.		
Estimated leakage factor	1.5			
Flux in core	154,200			
B in core	14,670.			


Scale
Deflector
Weight


Displacement of center
mm
0.020
0.010
Diaphragm 0.0375
Diaphragm 0.014
Diaphragm 0.0245
Grams weight added to center of diaphragm

Measurements of Diaphram Displacements. June 13th 92.

The following measurements were made of the bowing or displacement of circular clamped diaphrams under stresses applied at the center normal to the planes. The diaphrams were of mica in varying thicknesses, and weight were suspended from their center, the displacement being magnified by a beam of light on a pivoted mirror.

Thickness diaphram	Diam. of Diaphram	Distance h	Total Wt.	Scale deft. in divs.	Deviation produced divs.	Corrected divs. = elevation	Weight applied grms	Diaphram in cmd	Displacement per grm	Appl. for grm per sq. cm of diaphram			
0.0140	8.90	0.205	3.3	102.49	1.5	0.75	1.3	0.000120	4.155×10⁻⁶	1.617×10⁻⁴			
			4.3		3.	1.5	2.3	0.000300	1.305	1.827 -			
			7.3		9.	4.5	5.3	0.000901	1.70	2.380 -			
			12.3		19.	9.5	10.3	0.001902	1.846	2.584 -			
			22.3		41.	20.5	20.3	0.004104	2.022	2.831 -			
			52.3		107.	53.5	50.3	0.01071	2.129	2.980 -			
			27.3		54	27	25.3	0.005405	2.136	2.990			
			77.3		154	77.5	75.3	0.01531	2.033	2.846			
			127.3		234	117.5	125.3	0.02312	1.845	2.583			
			177.3		295.	147.0	175.3	0.02943	1.645	2.303			
0.0240	-	0.700	28		16	8	20.	0.003169	2.793×10⁻⁶	3.929×10⁻⁴			
			77		42.	21.5	75	0.0147	1.960	2.744 -			
			152.		76	38	150	0.02598	1.732	2.424 -			
0.0245	-	0.763	27		9.5	4.75	25	0.00354	1.416×10⁻⁶	3.469 -			
			77		28	14	75	0.01043	1.391	3.408 -			
			152		51	25.5	150	0.0190	1.267	3.103 -			
0.00375	-	0.7865	3.3		6	3.	1.3	0.00204	1.772×10⁻³	6.645×10⁻⁴			
			12.3		35	17.5	10.3	0.01364	1.324 -	4.8918			
			22.3		56	28.	20.3	0.0215	1.069 -	3.971			
			27.3		65	32.5	25.3	0.02496	9.874×10⁻⁴	3.702			
			52		102	51.	50	0.03917	7.834 -	2.938			
			27.		63	31.5	25	0.02420	9.68 -	3.630			
			77		128	63.75	75	0.04897	6.528 -	2.448			
			152.		182	90.25	150	0.06932	4.622 -	1.733			

Phonograph Battery Motor Design cont: from page 80.

Diameter of mean turn 1.94" = 0.5'

Total length of wire 64'

Res: of winding 0.056ω @ 20°C. 0.0636ω @ 60°C.

Weight - - 2.3 lbs.

Total weight of wire on motor 3.8 lbs.

Total resistance of motor 0.101ω @ 20°C 0.115ω @ 60°C.

Estimated Weight of field 3500 grm = 7¾ lbs.

" " " armature 5 "

" " " structure 1

Total " motor 13¾.

Local field produced by two neighboring teeth when the current in the armature is fwd

Local reluctance 0.076

Local mmf $\frac{7}{10} \times \frac{3}{2.5} \times \frac{4.5}{0.3}$ = 5.625]

Flux 77.4] or 77.4γ lines per tooth.

In the total polar ext mmf $\frac{7}{10} \times \frac{1}{0.3} \times 10$, 67.5]

Reluctance 0.038

Flux 2000γ

Particulars and Test of a Sample of Telegraph Cable Wire received from Schenectady 14th June 1892.

This wire was received in a coil of 15 turns each 12·5 cm. mean diam; = 587 cm. total length. It was labelled #14 B.S. 1 cent Japan. 1 Wrap of paper, 1 cent of Japan 2 papers. soaked in paraffine wax. Ext: diam 0·170". The insulation resistance of this length after 25 hours immersion in water was about 100,000 ω. & 24,000 ω after 60 hrs.

Thickness of diaphr	Diameter of Diaphram	Distance h	Total Wt	Scale div. div.	Deviation produced	Corrected Zero deviation	Weight applied grams	Displacement in cm	Displacement for 1 gram	Displacement per 1 gm per cm of thr
0.056	6.0	0.653	3.3	7648	~~7.48~~ 1	0.5	·1	2.365×10^{-3}	2.365×10^{-2}	2.619×10^{-4}
			4.3		2	1	2	0.000873	4.365×10	2.619
			7.3		4.5	2.25	5	1.964×10^{-3}	3.928	2.357
			12.3		9	4.5	10	3.928	3.928	2.357
			22.3		17	8.5	20	7.42	3.71	2.226
			52.3		35	17.5	50	15.28	3.056	1.834
			27.0		19.5	9.75	25	8.512	3.405	2.043
			77		47.5	23.8	75	20.78	2.771	1.663
			102		58	29	100	25.32	2.532	1.519
0.010	6.0	0.7295	27		18	9	25	8.78	3.512	3.512
			52		29	14.5	50	14.14	2.828	2.828
			77		38.5	19.25	75	18.78	2.504	2.504
			102		46	23	100	22.44	2.244	2.244
			152		58	29	150	28.29	1.886	1.886
0.0235	6.0	0.662	27		5	2.5	25	2.232	0.8925	2.080
			52		11	5.5	50	4.869	0.9738	2.28
			77		16.5	8.25	75	7.302	0.9736	2.287
			102		21.5	10.75	100	9.516	0.9516	2.236
			152		31	15.5	150	13.72	0.9147	2.150

It would appear from these results that to a first approximation and for small displacements of the diaphram this is expressable by the formula

$$d = k \cdot \frac{r}{t} \cdot p$$

where d is the displacement of the centre due to a stress applied centrally in a direction normal to the plane. cm.

r is the radius of the diaphram cm

t - - thickness - - - cm.

p - - - pull exerted

If p be expressed in grammes weight then for mica

$$d = 7.6 \times 10^{-7} \frac{pr}{t}$$

No. of Ma	P.D. at Motor terms	Current	Energy in Motor	Res. of Field	Drop in Field	Energy in Field	Energy in arm.	Res. of Arm.	Drop in Arm.	C.M. in Arm.	Effiet
1				19.25				33.0			-
2	511.6	0.080	0.413	211.3	19.25	7.95	3.2	208.1	33.	13.6	5.6	20.25
3	517.1	0.092	0.475	245.7	19.5	9.26	4.4	241.3	33.	15.7	7.5	23.8
4	520.6	0.160	0.825	429.5	19.75	16.3	13.5	416.0	34	23.1	23.2	33.8
5	515.6	0.179	0.923	476.2	20.0	18.47	17.1	459.1	35	32.3	29.8	42.3
6	515.6	0.216	1.115	574.8	20.25	22.58	25.2	549.6	36	40.14	44.8	52.8
7	514.5	0.259	1.337	687.8	20.75	27.74	37.1	650.7	37	49.46	66.1	58.6
8	514.5	0.286	1.476	759.2	21.25	31.36	46.3	712.9	38	56.10	82.8	63.1
9	511.0	0.380	1.961	1002.	22.25	43.62	85.5	916.5	39	76.48	150.0	75.5
10	504.5	0.362	1.868	942.4	23.25	43.43	81.14	861.3	40.35	75.36	140.8	72.5

Test of 500-volt Motor 1/2 H.P. 16th June 92

Three inches of platinoid wire #29 B.W.G. 0.0135" in diam. have been used to connect the armature with the commutator. The resistance of this wire is 0.1 ω per inch. The res. of each connection is thus 0.3 ω, and the res. of each armature section is 2.75 ω. Each local cct. is therefore increased by the wire in the ratio 3.35 : 2.75 = 22%.

The motor was coupled to the 120 volt machine of the same power, and the following results obtained.

Speed R.p.s.	C.M.F of arm.	E.M.F per Nor. for Arm.	Balance	Moment	6.65 × Moment	Delivery	Friction	Compm. eff.	Speed c.p.m	Total drop.
38.47	490.	12.74	50 @ 15" / 200 @ 10	2750	1.696 × 10^7	654	157.1	0.31	2208	21.55
34.33	492.1	14.33	50 @ 14 / 200 @ 10	4700	2.897	995	134.3	0.547	2060	24.96
31.0	476.2	15.37	50 @ 11 / 200 @ 14 / 500 @ 10	9650	5.95	1845	203.3	0.43	1860	44.4
29.33	464.8	15.84	50 @ 6 / 200 @ 5 / 500 @ 25	13,700	8.447	2477	171.6	0.520	1760	50.77
27.33	442.9	16.20	50 @ 30 / 200 @ 20 / 500 @ 25	18,200	11.22	3067	198.1	0.534	1640	62.74
26.0	437.3	16.22	50 @ 23.5 / 200 @ 5 / 500 @ 20	24,175	14.90	387	197.6	0.563	1560	77.20
25.0	427.0	17.09	50 @ 23 / 200 @ 15 / 500 @ 20	28,600	17.63	4441	189.1	0.581	1500	87.46
23.17	391.	16.88	50 @ 23.5 / 200 @ 15 / 500 @ 20 / 1000 @ 24	40,175	24.77	574	182.5	0.573	1390	120.1
23.17	385.7	16.65	50 @ 16 / 200 @ 15 / 500 @ 20 / 1000 @ 24	31,700	19.55	453	267.5	0.481	1390	118.8

Voltmeter Test 22nd June 1892.

The following voltmeters were standardised by Potentiometer & Clark cells.

1st Bardew voltmeter # 653 by Paterson & Cooper offering 347.5 @ 29°C and marked as offering 329.9 @ 19°C.

2nd Weston # 1664, belonging to Lamp Test Room, offering 15,840 @ 29°C.

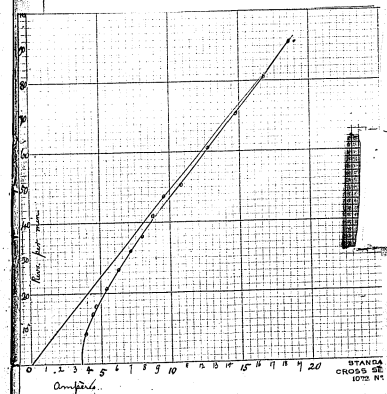
3rd " # 116 Direct & alternating current, belonging to Galvanometer Room 2062 @ 18°C

4th Howell # 214. Direct current not direct reading. 3889 @ 19°C

No. of Obs.	Potentiometer Observation		Howell	Diminishing of Howell Correction	Weston # 1664	Diminishing Correction	Weston # 116	Diminishing	Bardew	Diminishing
1	21.8				21.8	=	21.9	0.1 −	22	0.2 −
2	25.7				25.5	0.2 +	25.2	0.5 +	25	0.7 +
3	31.25				31	0.25 +	30.75	0.5 +	31	0.25 +
4	39.8				39.2	0.6 +	39.1	0.7 +	38.1	1.7 +
5	45.95				45.9	0.05 +	45.8	0.15 +	43.8	2.15 +
6	50.85				50.0	0.85 +	50.15	0.7 +	48.1	2.75 +
7	55.45				55.1	0.35 +	55.25	0.2 +	52.6	2.85 +
8	60.45				60.5	0.45 +	60.0	0.95 +	57.2	3.75 +
9	66.1				65.5	0.6 +	65.0	1.1 +	61.8	4.3 +
10	70.15				70.0	0.15 +	69.6	0.55 +	65.5	4.65 +
11	75.7				75.0	0.7 +	74.8	0.9 +	70.5	5.2 +
12	81.05				81.0	0.05 +	81.5	0.35 −	75.5	5.55 +
13	85.15				85.0	0.15 +	84.5	0.65 +	78.9	6.25 +
14	89.65				89.3	0.35 +	89.0	0.65 +	84	5.65 +
15	95.6				95.0	0.6 +	95.1	0.5 +	90.0	5.6 +
16	101.4		101.0	0.4 +	100.5	0.9 +	100.0	0.4 +	95.1	5.6 +
17	106.2		106.0	0.2 −	105.5	0.7 +	106.1	0.1 +	100.5	5.7 +
18	111.4		111.1	0.3 −	110.6	0.8 +	111.5	0.1 −	106.1	5.3 +
19	114.4		114.8	0.4 +	113.5	0.9 +	114.6	0.2 −	109.2	5.2 +
20	120.9		120.8	0.1 −	120.2	0.7 +	121.2	0.3 −	116.2	4.7 +
21	124.2		123.1	1.1 −	123.	1.2 +			119.	5.2 +

A
fig
Ex. 3.

Plate
1
2
3
4
5
6
7
8
9
10



STANDARD
CROSS SECTION
1072 N°

Tests of a new sample of zinc for Lalande cells.

A new brand of zinc from Pennsylvania is under trials. The first quality sold for 7½ per lb. is said to be almost chemically pure. The second quality sold for 6½ . . . . . 99% pure. The made up with the 100% and five more with the 99% zinc. Twenty two plates in all. The cells were set up on the 23rd June.

No. of plate	Weight 23rd June	Weight 14th July	Weight 30th Aug		No. of plate	Weight 23rd June	Weight 14th July	Weight 30th Aug	
						100%		99%	
1	271.0	267 4	248	17	11	303.5	301 2.5	296	5
2	256.5	250 6.5	230	20	12	299.0	297 2.0	292	5
3	290.0	287 3	270.5	6.5	13	319.0	316 3.	304	12
4	253.0	250 3	240.5	9.5	14	303.0	305 3.	291	14
5	280.5	279 1.5	272	7	15	308.5	306 2.5	301	5
6	250.5	249 1.5	243	6	16	301.5	297 2.5	294	3
7	255.0	254 1.0	248	6	17	291.5	289 2.5	282	7
8	293.5	292 1.5	285	7	18	288.5	286 2.5	279	7
9	251.0	248 3	244.5	3.5	19	291.0	289 2.	281	8
10	266.5	264 2.5	257	5	20	322.5	320 2.5	313	7
	2667.5	2640 27.5	2537.5	102.5		3033.0	3008 25	2933	75
		22.8	13.6				23.5 per plate	14.0 per plate	

Dimensions of zinc 3.78 per plate 100% 17.4 over all, 11.1 from shoulder, 7.75 broad, 0.442 thick
99% - - 0.508.

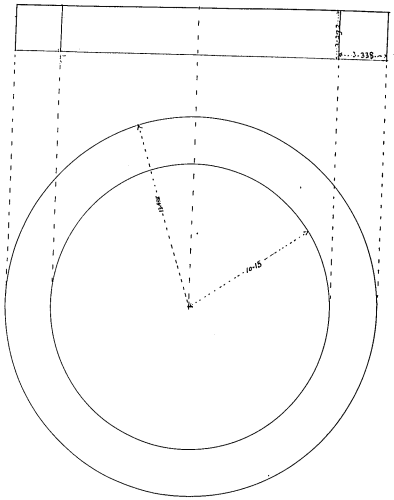
Cells left on open circuit

Test of alternating-current motor for patent case 27th June.

The first test on p. 76 showed that the fan blades were not large enough. They were now increased to aluminium plates 13.25 square whose centres are in the same plane 24.3 distant. The following results were then obtained

No. of obs	Ohmic	Amp	Lamps	Rpm.	R.p.m per amp	R.p. sec.	R.p. sec per amp
1	0.744	3.839	9	8.5	2.214	0.142	
2	0.833	4.299	10	14.0	3.257	0.233	
3	0.885	4.566	11	16.2	3.548	0.27	
4	1.041	5.372	13	21.3	3.965	0.355	
5	1.212	6.253	15	26.7	4.269	0.445	
6	1.370	7.070	17	32	4.526	0.533	
7	1.545	7.972	19	36	4.516	0.6	
8	1.710	8.824	21	42	4.760	0.7	
9	1.855	9.570	23	47.5	4.963 ?	0.779	
10	2.077	10.720	25	50.5	4.712	0.842	
11	2.467	12.730	30	61	4.792	1.017	
12	2.860	14.760	35	71	4.811	1.183	
13	3.230	16.670	40	81	4.859	1.35	
14	3.60	18.58	45	91	4.899	1.517	

Plan and Diametral Section of Ring #1. – Submitted to our inventing

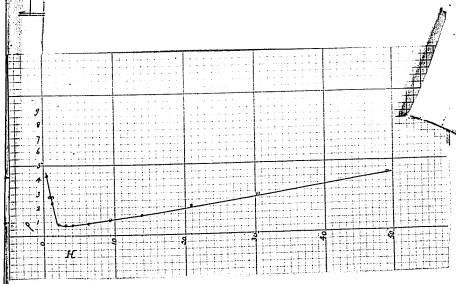


External	Radius	13.488	Diameter	26.976	Circumference	84.76	Radⁿ 181.9
Internal	"	10.15	"	20.3	"	63.78	" 103.02
Mean	"	11.819	"	23.638	"	74.26	" 78.88

Mean Radial depth	3.338
" height	2.292
" Cross section	10.99 cm²
Plane area	247.8 "
Volume by measurement	816.0
Mass observed	7684.9
Sp. gravity	6.906
Primary winding	183 turns
Secondary "	50 "

$$\frac{183}{74.26} = 2.464 \times \frac{4\pi}{10} = 3.097.$$

h_1	Obsd
1	0.038
2	0.085
3	0.07
4	0.121
5	0.18
6	0.2
7	0.3
8	0.5
9	0.8
10	1.2
11	1
12	3
13	5



Test of Malleable Iron Samples from Trenton N.J.

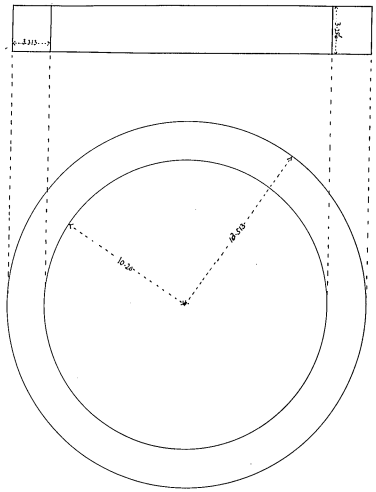
24th June.

	Source of EMF	EMF at temp.	Capacity	q.	Mean thickness	q. per div.
	1.66 @ 256°C.	1.426×10^{8}	1×10^{-11}	1.426×10^{-7}	150.8	9.454×10^{-10}

No. of Obs.	Obs.	Amp.	H	No. of Turns	Mean thickness	q.	No. of Gal. det.	Total Flux of Gal. det.	10 Kq	B	μ	ρ
1	0.0321	0.160	0.4954	4	295	2.411×10^{-8}	0	5350	12,900	1174		4.22×10^{-7}
2	0.0565	0.2915	0.9026	4	69.75	6.514	0	"	35,280	3241		2.811
3	0.0735	0.3792	1.174	3	110	10.4	0	"	55,640	5063		2.319
4	0.1255	0.6475	2.005	4	171.4	16.21	10,000	15,350	248,800	2264		0.8856
5	0.1825	0.9415	2.916	4	153.1	14.47	25,000	30,350	439,200	3996		0.7298
6	0.2525	1.303	4.035	3	206	19.48	"	"	591,300	5380		0.750
7	0.3885	2.004	6.206	4	151.5	14.33	50,000	55,350	793,200	7218		0.8598
8	0.5775	2.980	9.228	4	177.5	16.78	"	"	929,800	8452		1.092
9	0.863	4.453	13.790	4	198	18.72	"	"	1,036,000	9428		1.463
10	1.305	6.734	20.85	4	217.5	20.56	"	"	1,135,000	10,360		2.013
11	1.90	9.804	30.36	4	236.25	22.34	"	"	1,237,000	11,260		2.696
12	3.070	15.84	49.05	4	254.5	23.78	"	"	1,316,000	11,980		4.094
13	5.700	29.416	91.08	4	278.75	26.36	"	"	1,459,000	13,280		6.860

181.9
103.02

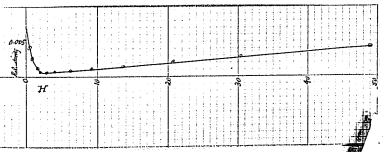
Plan and Diametral section of Ring # 2.



External	Radius	13.513	Diameter	27.026	Circumference	84.92	Rad²	182.5
Internal	"	10.20	"	20.40	"	64.09	100 a.f.	
Mean	"	11.857	"	23.713	"	74.51		78.46

Mean radial depth	3.313
Mean height	3.286
Cross-section	10.886 cm²
Plane area	2869.5 "
Volume by measurements	~~[illegible]~~ 9 10.54 c.c.
Observed mass	5684.0 gms.
Sp. g. by measurement	6960 7.0114
Primary winding	183 turns
Secondary winding	50 "

$$\frac{H}{\gamma} = \frac{183}{74.51} \times 1.2566 = 3.086$$

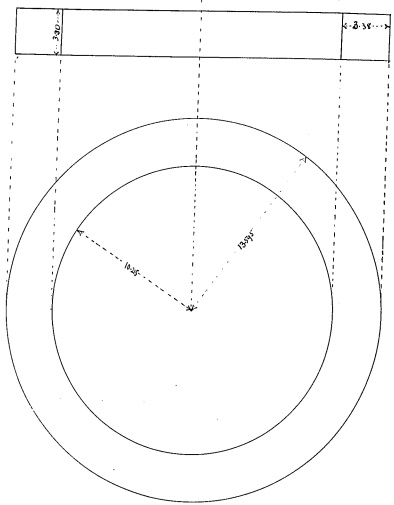


Test of Malleable Iron Sample from Trenton contd.
25th Nov.

Thy Obs	Obs. ch	Amp.	H	No. of Turns	Mean Turns	q	Rec. ratch to q. ct.	Total Rec. of q. ct.	q	B	μ	ρ	
1	0.031	0.160	0.494	3	25.75	2.453×10^{-3}	0	53,50	1,312	120.5		$4 - 10 \times 10^{-3}$	
2	0.0565	0.2415	0.900	3	73.75	6.972.	0	"	3,730	342.6		2.627.	
3	0.0735	0.3792	1.170	3	128.5	1.404×10^{-2}	0	"	7,510	689.8		1.696.	
4	0.1255	0.6475	1.998	3	229	2.165.	10,000	15,350	33,230	3052.		0.6046	
5	0.1825	0.9415	2.905	3	176.9	1.672.	25,000	30,350	50,740	4661.		0.6233	
6	0.2525	1.303	4.021	3	224.7	2.124.	"	"	64,470	5922.		0.679	
7	0.3185	2.004	6.185	4	150.6	1.424.	50,000	55,350	78,820	7240		0.8522	
8	0.5775	2.980	9.198	4	173	1.636.	"	"	90,550	8318		1.106	
9	0.863	4.453	13.74	4	195	1.843.	"	"	102,000	9370		1.467	
10	1.305	6.734	20.78	4	210.6	1.991.	"	"	110,200	10,120		2.053	
11	1.90	9.804	30.25	4	220.8	2.087.	"	"	115,500	10,610		2.851	
12	3.070	15.84	48.89	4	242.3	2.291.	"	"	126,800	11,650		4.196	
13	5.700	29.46	90.78	4	266.5	2.520.	"	"	139,500	12,810		7.088	

Source of EMF	EMF at temp	Capacity	q.	Mean Throw	q. per div.
16 cells @ 1.56 c.	1.426×10^{8}	1×10^{-15}	1.426×10^{-7}	156.8	9.1024×10^{-10}

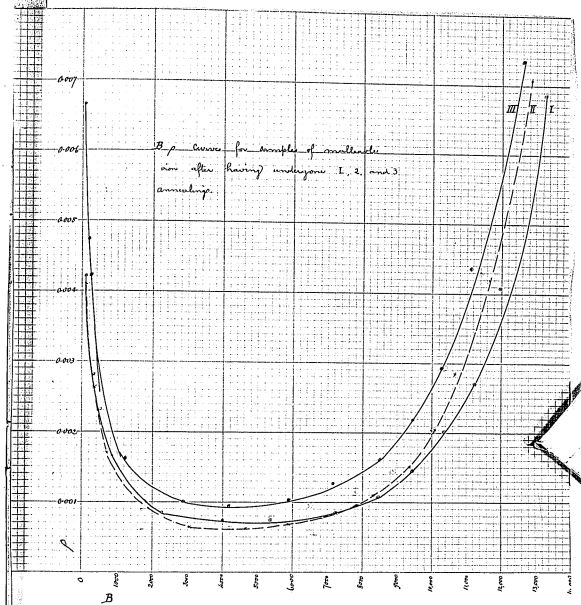
Plan and Diametral Section of Ring # III (Was undergone three annealing)



External Radius	13.895,	Diameter	27.79,	Circumference	85.42	Rad² 194.82
Internal -	10.215		20.43	-	64.19	- 104.34
Mean	11.905		23.81	-	74.80	80.48

Mean radial depth	= 3.380 c.
Mean height	3.30
Cross section	11.154 c.c.
Plane area	252.8 c.c.
Volume by measurement	834.4 c.c.
Observed Mass	5684 g.
Sp. g. by measurements	6.812
Primary winding	183 turns
Secondary -	50 -

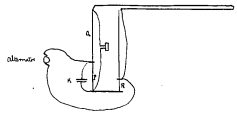
$$\frac{H}{\gamma} = \frac{183}{74.8} \times 1.2566 = 3.075$$



Plan . . a.

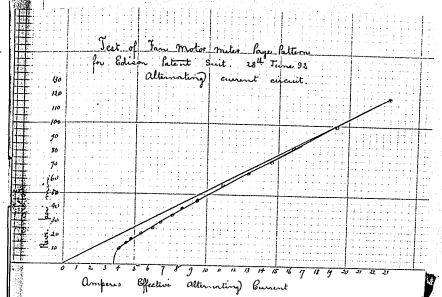
Test of Sample of Malleable Iron from Trenton N.J.

Obs. No.	Obs.	Amp.	H	No. of Turns	Mean Turns	φ	Res. add. to g. cct.	Res. of g. cct.	F	B	μ	ρ
1	0.031	0.160	0.492	3	16.3	1.574×10^{-5}	0	5350	8243	73.9		6.66×10^{-7}
2	0.0565	0.2915	0.896	3	41.8	3.452	0	"	2,114	189.6		4.726
3	0.0735	0.3792	1.166	3	60.8	5.748	0	"	3,075	275.7		4.229
4	0.1255	0.6475	1.991	4	94.75	8.957	10,000	15,350	13,750	1233.0		1.615
5	0.1825	0.9415	2.895	4	111.5	1.054×10^{-7}	25,000	40,350	31,990	2868.		1.010
6	0.2525	1.303	4.006	3	162.7	1.538	"	"	46,650	4185.		0.957
7	0.3885	2.004	6.162	4	126.2	1.193	50,000	55,350	66,040	5922		1.041
8	0.5775	2.980	9.164	4	153	1.446	"	"	80,040	7176		1.288
9	0.863	4.453	13.69	4	180.75	1.709	"	"	94,600	8482		1.611
10	1.305	6.734	20.71	4	201	1.90	"	"	105,200	9430		2.197
11	1.900	9.804	30.14	4	219	2.07	"	"	114,600	10,275		2.934
12	3.090	15.84	48.71	4	237.2	2.242	"	"	124,100	11,130		4.377
13	5.700	29.416	90.43	4	262.5	2.472	"	"	137,400	12,320		7.342
	Source of EMF		EMF at temp		Capacity		φ		Mean Turns		φ per div	
	1 Bunsen @ 25.6°C		1.426×10^{-8}		10^{-5}		1.426×10^{-7}		150.8		0.9454×10^{-3}	



$$\lambda = 4 \log_{3.1} \frac{h}{r} = 4 \log_e \frac{4.5}{0.036} = 4 \log_e 125.5 = 4.2104 \times 2 \times 1248 = 19.57 + 1 = 20.57$$

$$20.57 \times 1380 = 28400$$



Test of Alternating Current Motor Meter 28th June 92.

The instrument after having been tested on continuous current, was excited by alternating-current transformer, using 140 volts in the secondary, through Siemens Dynamometer and Lamp-Bank.

Exp. No	Degrees	√θ	Ampere	Revs. per min	Revs. per sec	Ampsq.	Rps per	Observed Drop	λ
1	19°	4·359	3·988	11	0·183	2·758			10
2	23·5°	4·848	4·436	15	0·25	3·381			11
3	26·5°	5·148	4·710	18	0·3	3·822			12
4	36°	6·0	5·489	21·75	0·363	3·962			14
5	46°	6·782	6·205	26·3	0·438	4·239			16
6	55°	7·416	6·786	30	0·5	4·421			18
7	69°	8·307	7·60	35	0·583	4·605			20
8	83°	9·110	8·336	40	0·6	4·797			22
9	105°	10·247	9·377	45·5	0·758	4·853			25
10	145·5°	12·185	11·15	56	0·93	5·023			30
11	200°	14·142	12·94	65	1·083	5·023			35
12	253°	15·906	14·55	73	1·218	5·018			40
13	311°	17·635	16·135	83	1·383	5·145			45
14	40°	6·325	19·07	99·5	1·658	5·218			55
15	55°	7·416	22·36	119	1·983	5·322			67
16	54°	7·348						2·6 volts	

Res. of instrument warm 0·139 ω.

Measurement of Inductance June 29th

A metre bridge was arranged for the measurement of small inductance. The wire was 100 cms. long on the bridge scale and also 100 cms. long on the comparison scale; it was of platinoid, and had a diameter of 0·018. Its resistance is 0·14417 ω per cm. = 0·14372 Tum ohms. Balance was first obtained with a battery, and then the battery was replaced by the unscreened alternator, giving some 1140 ~ per second. The insertion of a condenser with a very slight readjustment of the bridge restored silence in the telephone.

A loop of soft copper wire was stretched along the floor. The length of each side, 1380, the diameter of the wire 0·072, and the distance 4·8 between axes.

P = 42·35 R = 6·9 ∴ P = 6·087 ω R = 49·918 ω
Q = 47·65 K = 3·365 ω Q = 6·85 ω

$\rho = \frac{QR}{P} = 1·116$ ω.

$l = \rho K P = 1·116 \times 6·087 \times 3·365 = 22·86$ microhenrys

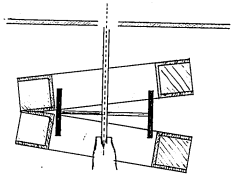
Calculated inductance 28·44 microhenrys. The condenser K consisted of 0·01

Repetition of test after making several improvements in connections.

P = 54·73 R = 10·15 P = 7·865 R = 4·458
Q = 45·27 K = 3·13 Q = 6·506

$\rho = \frac{QR}{P} = 1·206$ ω

$l = \rho K P = 1·206 \times 7·865 \times 3·130 = 29·7$ microhenrys.



Physiological Experiments 8th July 92.

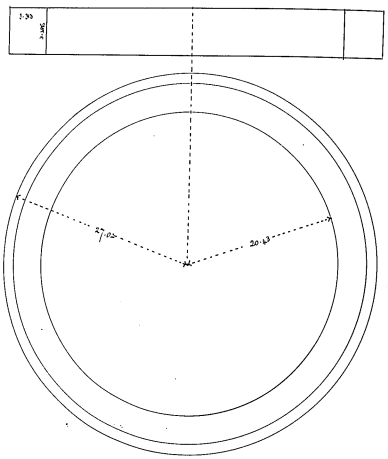
Dr Frederick Peterson prepared a slide with some freshly collected ciliated epithelium from the throat of a freshly skin frog. This slide was examined under a microscope when placed in a horizontal position between the conical pole of the large electromagnet, the air gap being about 1 cm. Exciting or relaxing the magnet had no apparent effect on the movements of the cells. Blood was next tried with no better success.

The web in the foot of a living frog was next tried, the web was extended in the horizontal plane with the poles about 1·5 apart. The circulation was clearly visible, but no magnetic effects could be observed.

On attaching one wire to a toe, and another to the foot above the ankle, so as to pass a current through the limb under examination, and after care had been exercised (by injecting subcutaneously) to stop the muscular twitch on making and breaking contact, it was observed by Dr Peterson that a current of one milliampere through the foot would arrest circulation. There would be a momentary stimulus on closing the circuit, followed by an abatement of activity, until within about ten seconds the circulation would have stopped in most of the vessels. On breaking the circuit the circulation would slowly reestablish, until in about ten seconds the flow with apparently normal rapidity. This observation was repeated several times.

A brown terrier dog was chloroformed, and experiments made with an induction coil worked by battery to ascertain if any motor areas in the brain could be stimulated through the skull by using needles close together. No success could be obtained, although superficial nerves and muscles could be stimulated. It would appear that the highly vascular nature of scalp and skull short circuited the stimuli and prevented the current from the needles, reaching down into the brain substance. Even when the skull was broken, and the needle let down through the incision no effect was visible, the blood apparently short circuiting.

Plan and Diametral Section of Ring #1 w.



External Diameter	27.02	Radius	13.51	Circumference	84.9	Rad.ᵃ	182.5
Internal "	20.43		10.215	"	64.18	"	104.39
Mean "	23.725		11.863	"	74.54		78.16

Mean Radial depth	3.313
" height	3.286.
" cross section	10.89
Plane area	245.6
Volume by dimensions	807
Observed mass	5641
Sp. g. by dimensions	6.99.
Primary winding	183 turns
Secondary "	50

$\frac{H}{\gamma} = \frac{183}{74.54} \times 1 = 2.566 \qquad = 3.086.$

Test of sample Malleable Iron Rings.

(21)

	No 1	No 3.	No 4	No 5.	No 2 w	No 3 w.
External Radius	13.91	13.75	13.618	13.587	13.582	13.563
" Diameter	27.82	27.49	27.235	27.173	27.163	27.125
" Circumference	87.38	86.4	85.5	85.4	85.4	85.2
Internal Radius	10.39	10.26	10.208	10.264	10.194	10.163
" Diameter	20.78	20.51	20.415	20.527	20.387	20.325
" Circumference	65.28	64.4	64.1	64.5	64.0	63.8
Mean Circumference	76.33	75.4	74.8	74.95	74.7	74.5
Mean Radial depth (Radᵃ)	3.524	3.488	3.410	3.323	3.388	3.400
" Height	2.945	3.121	3.320	3.310	3.270	3.280
" Cross section	10.38	10.89	11.32	11.0	11.08	11.56.
" Plane area	267.2					
" Volume by dimensions	792.2	821.0	845.2	824.4	827.6	861.2
Observed mass	5443 12 lbs.	5698 12 lb. 9 oz.	5854 12 lb. 10 oz	5882 12 lb. 8 oz	5698 12 lb. 7 oz	5726 12 lb. 10 oz
Mean sp. g. by dimensions	6.87	6.94	6.81	7.135	6.814	6.65
Primary winding	183	183	183	183	183	183
Secondary winding	49	50	50	50	50	51
H/γ	3.013	3.05	3.075	3.068	3.079	3.085

Ring #2 whose test appears on page 87, was broken up to examine the iron in the interior. It proved to be in fairly good condition throughout.

Ring #3 was heated in the forge and hammered by hand. Its height was thus reduced from 3.30 to 3.12, the radial width being increased from 3.38 to 3.41 by the same operation. The mass was 5684 before and 5698 after.

Ring #1 was heated in the forge and compressed by drop hammer. Its height was reduced from 3.29 to 2.945, and its radial breadth increased from 3.34 to 3.52. The mass was reduced from 5635 to 5443 but the apparent sp. g. underwent very little change.

Ring # 1

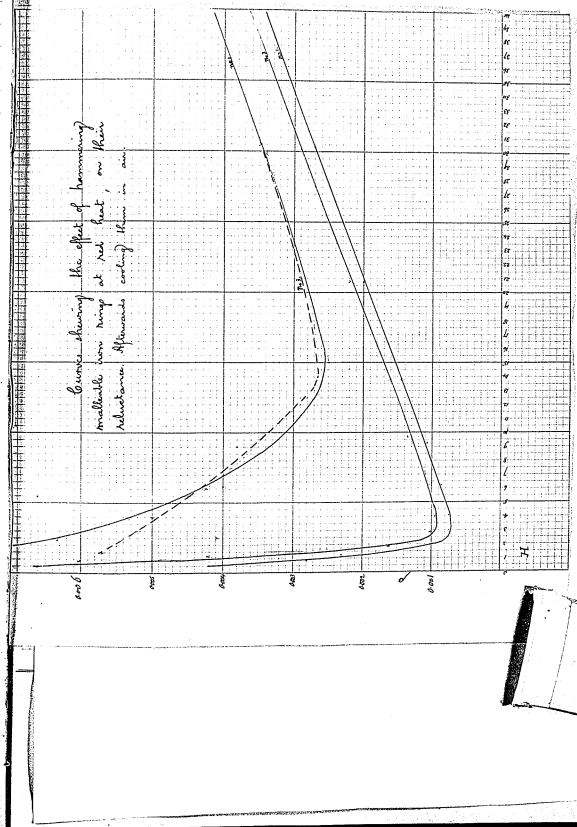
No. of Obs.	Obserd.	Compt.	H	Lift of Cylinder in ft.	Rise of Cylinder		H	Mean Thrust	q $\times 10^{-8}$	F	B	ρ $\times 10^{-3}$
1	0.024	0.1238		0	5300	8400 / 2196	0.73	9.75	0.892	482	46.4	8.038
2	0.0542	0.2797		0	"		0.8427	23.3	2.131	1,152	111.0	7.592
3	0.0664	0.3424		0	"		1.032	26	2.378	1,285	123.8	8.336
4	0.0964	0.4974		10,000	15300	15600 / 18,000	1.498	13	1.189	1,854	178.7	8.383
5	0.1574	0.8122		"	"		2.448	28.1	2.57	4,009	386.2	6.339
6	0.2423	1.250		25,000	30,300	30900 / 29,900	3.766	24.8	2.268	7,332 / 7,100	706.8	5.329
7	0.3621	1.869		"	"		5.631	46.5	4.253	10,400 / 10,700	1267	4.444
8	0.5457	2.817		50,000	55,300	54,400 / 54,220	8.487	45.1	4.125	23,260	2241	3.787
9	0.816	4.211		50,000	"		12.68	96.3	8.809	49,680	4786	2.649
10	1.263	6.52		50,000	"		19.64	142.3	13.02	73,420	7074	2.777
11	1.916	9.888		50,000	"		29.79	175	16.01	90,300	8699	3.425
12	3.087	15.92		50,000	"		48.0	205	18.75	105,750	10,185	4.713

Ring # 3 ~ 51

No. of Obs.	H	Mean Thrust	q $\times 10^{-8}$	F	B	ρ
1	0.38	37.1	3.393	1763	152.5	2.492
2	0.86	107.5	9.834	5110	442	1.946
3	1.06	142	12.99	6750	583.9	1.815
4	1.54	134.4	12.29	18,450	1594	0.966
5	2.51	344.4	31.50	47,250	4087	0.615
6	4.05	208	19.02	56,400	4886	0.829
7	6.06	280.8	25.69	76,300	6600	0.918
8	9.13	179	16.37	81,750	7677	1.189
9	13.00	201.8	18.46	100,100	8660	1.501
10	20.12	224.5	20.99	113,800	9844	2.0244
11	30.5	250.5	22.91	124,200	10,740	2.640
12	49.2	268.3	24.54	133,050	11,510	4.275

Ring #3

No. of Obs.	H	Mean Thrust	q $\times 10^{-8}$	F	B	ρ
1	0.38	11.5	1.052	557.5	51.18	7.425
2	0.86	31.8	2.909	1512	141.6	6.074
3	1.06	31.8	2.909	1512	141.6	7.488
4	1.54	21	1.921	2939	269.9	5.705
5	2.51	47	4.299	6578	604	4.155
6	4.05	31.8	2.909	8811	809.4	5.004
7	6.06	56	5.122	15,820	1425	4.253
8	9.13	56.8	5.198	28,740	2639	3.146
9	13.00	102.3	9.359	51,750	4752	2.736
10	20.12	151.5	13.86	76,640	7038	2.857
11	30.5	187.5	17.15	94,930	8710	3.501
12	49.2	221.0	20.21	111,600	10,250	4.80



Collection of Tests on seven malleable Iron Rings.

Ring #1.

H	Mean Throw	q ($\times 10^{-5}$)	F	B	ρ (10^{-3})
0.382	14.3	4.144	2,196	201.6	1.895
0.863	12.56	9.660	5,120	470.1	1.836
1.057	164.3	15.03	7,966	731.6	1.445
1.535	167.5	15.32	23,440	2152.	0.7132
2.507	347.	31.74	48,560	4459	0.562
4.051	212.	19.39	58,750	5395	0.751
6.056	263.	24.06	72,900	6694	0.905
9.128	162.5	14.86	88,170	8096	1.128
12.99	183.	16.74	92,570	8501	1.528
20.12	220.8	20.20	111,700	10,260	1.961
30.51	233.3	20.43	113,000	10380	2.939
49.16	246.	22.50	124,400	11420	4.304

Ring #2.

H	Mean Throw	q ($\times 10^{-5}$)	F	B	ρ
0.38	40.2	3.677	1949	175.9	2.160
0.86	123.5	11.3	5989	540.5	1.591
1.06	182.3	16.67	8835	797.4	1.329
1.54	176.5	16.14	24,700	2229	0.691
2.51	338.8	30.98	47,400	4278	0.587
4.05	204.	18.66	56,540	5102	0.794
6.06	253.5	23.19	70,260	6341	0.956
9.13	164.5	15.05	83,220	7510	1.216
13.00	186.8	17.09	94,500	8528	1.525
20.12	212.	19.39	107,200	9674	2.080
30.5	226.3	20.7	114,500	10,320	2.952
49.2	237.	21.68	119,900	10,820	4.526

Square of Emf	EMF at temp	Capacity	q.	Mean Throw	q. per turn	No. of Throws
1. C.C.O 216	1.4295	18	1.4295×10^{-7}	156.3	9.148×10^{-10}	8

Ring #4.

H	Mean Throw	q (10^{-5})	F	B	ρ
0.38					
0.86					
1.06					
1.54	142.0	12.99	19,880	1756	0.877
2.51	342.5	31.23	47,780	4220	0.595
4.05	220.2	20.14	61,020	5390	0.751
6.06	264.3	24.18	73,260	6472	0.937
9.13	175.0	16.01	88,530	7821	1.168
13.00	200.0	18.29	101,140	8934	1.455
20.12	223.0	20.4	112,800	9964	2.019
30.5	231.5	21.18	117,100	10,345	2.948
49.2	255.2	23.33	129,000	11,395	4.318

Ring #5.

H	Mean Throw	q (10^{-5})	F	B	ρ
0.38					
0.86					
1.06					
1.54	128	11.71	17,920	1629	0.945
2.51	306.8	28.06	42,920	3903	0.643
4.05	198.5	18.16	55,020	5002	0.810
6.06	252	23.05	69,840	6349	0.954
9.13	164.8	15.08	83,380	7580	1.204
13.00	191.8	17.54	97,000	8820	1.474
20.12	203.5	18.61	102,900	9355	2.157
30.5	237.5	21.72	120,100	10,827	2.817
49.2	242.	22.23	122,900	11,175	4.402

Test of an Ernst Storage Cell July. 8th 92.

This arrangement of plates in this cell forms a mass 15·9 x 17.2 x 24 high. There are 13 horizontal plates, 7 + and 6 interleaved —. The flat surfaces of each side = 275 sq. cms., and the active (flat) surface on each whole plate or electrode = 3300 sq. cms. The weight of all 13 plates and their frames dry = 46·5 lbs = 21·1 kilos. Each plate averages with attachment 3·6 lbs. or 1·6 kilos. The total weight of the cell is 35·1 kilos or 77 lbs with 7000 c.c. of dilute H_2SO_4 of density 1·17 @ 20°C.

The cell was set up on the 7th July, and tested on the 8th. Its EMF was then 1·6 volts. It was discharged through 1 ω for four hours when the p.d. was 0·6 volt. It was then charged from the 100 volt circuit through a lamp bank.

Date	Time	Hrs. Mins	Total Hrs.	Current by Potentio	Mean.	Amp. Hrs.
July 8th	14.45			5.42		
"	18.00	3.15		5.88	5.65	17.8
" 9th	8.40			5.60		
"	13.0	4.20	7.35	5.86	5.73	24.1
" 10th	8.10			4.31		
" "	12.0	3.50	11.25	4.60	4.46	15.6
" "	12.20					
" "	18.00	5.20	16.45	4.50		
" 12th	9.0			4.97	4	
" "	12.0	3.0	19.45	5.0	5.0	
" 11	13.0			-		
" "	18.0	5.0	24.45	5.95		
" 13th	9.0			6.0	6.0	
" "	12.0	3.0		-		

July 14th Discharged cell direct through large meter 0·3764 ω @ about 6 amp

Weight of zinc plate			
Before	44·220	47·260	
after	44·185	47·205	
	·035	·045	Mean 0·040 X 1·1228 = 44912

Result 45 amps hr

July 15th Charged cell through meter at 10 amp. P.D. 1 volt on 0·1 ω

Before	46·595	42·810	
	46·505	42·880	
	·090	·070	Mean 0·080 X 1·1228 = 89.624

July 16th Discharged cell through meter direct about 6 amp

Before	45·220	47.155	
	45·175	47.207	
	·045	·052	Mean 0·0485 X 1·1228 = 54.45

July 18th Charged cell @ 5 amp but charger missed.

21st Discharged cell before	41·570	45·250	Thos meter
after	41·555	45·280	
	·015	·020	Mean 0·0175 X 1.1228 = 19.65

July 22nd Charged cell @ 6 amp

	43·517	44·790	44·185	44·250	
after	43·470	44·740	44·235	44·200	
	·033	·050	·050	·050	Mean 0·051 X 1·1228 = 57.4

23rd Discharged

Before	43·355	43·835	45·555	42·910	
after	43·325	43·865	45·550	42·940	
	·030	·030	·030	·030	Mean 0·030 X 1·1228 = 33.7

Loss in feeder #1 $\frac{1187}{1064.5}$ $\frac{1064.5}{122.5}$ = 10.32 % in feeder #1

" " cons: cct. #1 $\frac{1064.5}{1023.}$ $\frac{}{41.5}$ = 3.9 % - main

" " feeder #2 $\frac{1219}{1152}$ $\frac{}{67}$ = 5.5 % - feeder #2

" " cons cct. #2 $\frac{1152}{1080}$ $\frac{}{72}$ = 6.67 % - main #2.

Alternating Current Primary Pressures measured in Newark N.S. by Mr Hammer. 2nd July 22 (94)

End of Feeder #1 20.45 vol: Leg: Dept: voltmeter + 500 ω res: connected to neutral and negative terminals of 80 kt 4 KW. transformer from Laboratory 103 volts @ 75° F Ratio of this transformer = 500 : 50 = $\frac{25}{1}$ Res: of voltmeter # 238 2083 ω (2083 + 500)/2083 = 1.240 × 8.3 = 10.335 multiplier

103 × 10.335 = 1064.6 volts.

L.S. bus bars at 20.45 vol. Laboratory voltmeter, 20,000 ω 111 volts @ 75° F

Res: of 20,000 ω = 19,978 Res: of voltmeter # 116 = 2060 ω @ 80° F.

$\frac{19,978}{2060}$ = 9.698 + 1 = 10.698 multiplier. 10.698 × 111 = 1187

Far end of consumption circuit fed by #1 21.10 vol. Leg. Dept. Volts: 99 @ 75° F

99 × 10.335 = 1023

L.S. bus bars as before 111 @ 75° F = 1187.

Far end of consumption circuit fed by #2. 22 vol. Legal Dept: volts:

104.5 volts @ 72.5° F 104.5 × 10.335 = 1080

L.S. bus. bars at the same time Lab: volts 114 @ 83° F = 1219

End of Feeder No. 2. 22.20 vol:

Legal Dept. volts: 111.5 @ 72.5° F = 1152 volts.

L.S. bus at same time. Lab. voltmeter 115 volts @ 83° F 115 × 10.698 = 1230.

Secondary tests

	No 1.		No 2.		
End of feeder	50 volts @ 9.50 pm:	(C.S. bus 114)	53 vo: @ 10.25 pm:	(C.S. bus = 116)	
Half way on Cons: Cct.	48 "	9.40 -	(C.S. - 112)	52 -	10.20 - (C.S. - = 115)
End of cons: cct	47 -	9.20 -	(C.S. - 111)	52 -	10.05 - (C.S. - = 114)

No 2.

Tests taken on the 3rd July.

24,002 ω total res: of cct (11,977 + 9965 + 2060 ω) including # 116 = multiplying power $\frac{24,002}{2060}$, 11.65. Buchan p. d. 1270.

Measurement of Inductance in Iron.

A straight length of wooden moulding with a groove 1.3 cms wide was selected, about 4.25 cms long. A galvanised iron wire 0.158 (0.062" # 14 B.W.G.) such as is used in telephone work, was doubled, and the loop fixed in this groove, the sides being pressed against the walls of the groove by copper tacks. The axes of the wires were thus separated by a distance of 1.142 cms.

The resistance of the loop by bridge 1000 ~ was 0.612 ω. with Galvo. With the unexcited alternator as E.M.F. and a telephone in place of Galvo the balance was 1000 ~ 0.631 ω = 0.130 %. This balance silenced the principal note, but there appeared to be higher residual notes that ~~to~~ no adjustment was found to suppress.

0.631 × 1000 × 0.130 = 5203 microhenrys = 82030 cms = 192.2 cms for one of loop.

By theory L_t = 4 $\log_e \frac{b}{r}$ + μ

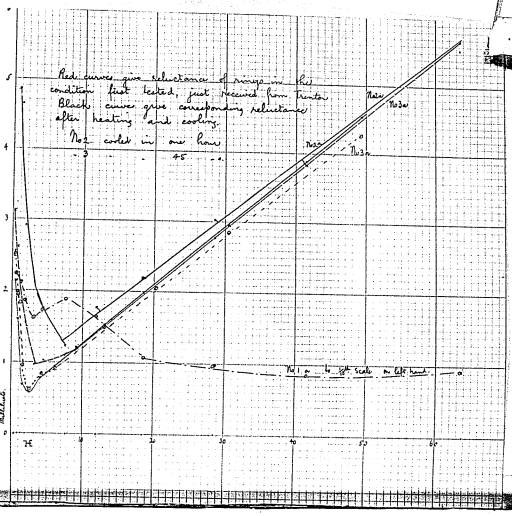
192.2 = 10.68 + μ

μ = 181.52

In this case b = 1.142 r = 0.079

b/r = 14.45 $\log_{10}$ 14.45 = 1.16017 × 2.3026 = 2.67

2.67 × 4 = 10.68


Red curves give reluctances of irons in the condition first tested, just received from Trenton.
Black curves give corresponding reluctances after heating and cooling.
No 2 coded in one hour
No 1 on left hand scale
No 2a
No 2
No 3
H
10
20
30
40
50
60
Reluctance

Experiments on the annealing of malleable iron rings

[illegible] 1a and 3a of pages 91 & 92 were stripped of wire, taken to [illegible] forge & heated to a full red heat. No 1a was promptly chilled by [illegible] in water. It had nearly reached the temperature of the surrounding [illegible] in one minute. No 2a was allowed to cool on ashes in a [illegible]. It was cool in about one hour. No 3a was allowed to [illegible] in an ~~slow~~ extinguishing bucket full, and was cool in [illegible]nt 45 hours. The three rings were then removed and tested. [illegible]ure were 50 hours in each secondary and 176 in each primary.

[illegible] of Bars	EMF at temp	Capacity	q.	Mean theo	No. of turns	q per div	Mean
1a	1.4236×10^{-1}	10^{-95}	1.4236×10^{-7}	149.2	11	0.9562×10^{-7}	
2a 2b 2c	1.4247		1.4247	148.9	7	0.9566	0.9549×10^{-7}

Mean ci: 74.7

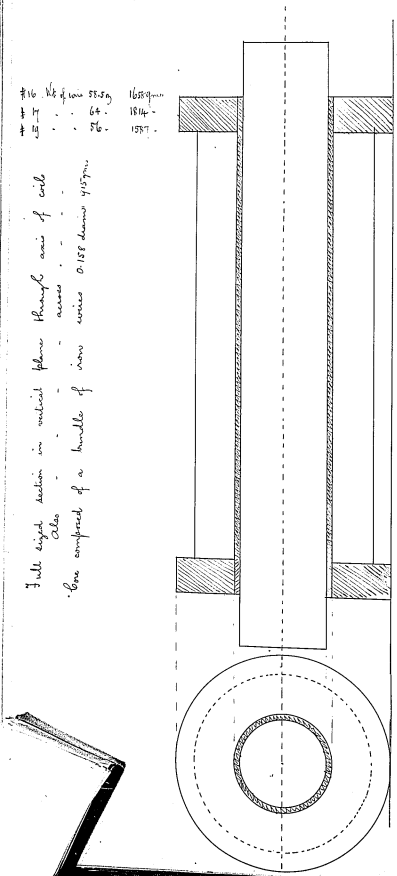
$\frac{176 \times 1.2567}{74.7} = 2.961$

When these rings are suspended by a cord in the a vertical plane, they strike gently in their own plane about the midway.

signifies the note 3a

1a	- -	83524.1760
2a	- -	9988.1680
3a	- -	$10,240.0\,F_{2000}$

[illegible]	Temp.	H	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.021	0.1183	0.2207	0	53.80	3	10^{-95} 0.3565	158.1	144.5	22.06	21.7	10^{-95} 20.72	1115	1.01.6	1.1.6	1.1.6	1.1.6	1.1.6	1.1.6	1.1.6	1.1.6	1.1.6	1.1.6	1.1.6	1.1.6	1.1.6	1.1.6	1.1.6	1.1.6	1.1.6	1.1.6
0.0155	0.2535	0.5841	-	-	9	8.594	146.3	122.5	19.8	37.4	35.71	1721	1734	254.2	6.70	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96
0.077	0.3475	1.177	-	-	11.5	11.27	140.3	57.7	21.14	52.8	52.22	2516	2516	2516	2516	2516	2516	2516	2516	2516	2516	2516	2516	2516	2516	2516	2516	2516	2516	2516
0.128	0.6605	1.956	-	-	21.3	20.34	109.4	109.5	83.55	144.5	138.0	7.1.6.4	6.70.0	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92
0.234	1.053	3.115	0.000	10.380	21.3	20.34	21.15	261.1	16.06	16.85	157.4	1.6.5.0	1.4.5.0	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5
0.297	1.539	4.579	0.000	38.380	9.8	9.358	28.43	17.37	17.37	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8
0.477	2.565	7.595	50.000	50.000	8.5	7.925	43.38	261.1	16.06	16.85	157.4	1.6.5.0	1.4.5.0	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5
0.732	4.095	11.95	-	-	15	14.32	33.9	14.38	10.71	17.59	16.7	1.6.5.0	1.4.5.0	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5
1.298	6.234	18.96	-	-	35.5	59.5	56.42	21.4	8.472	228	217	1.6.5.0	1.4.5.0	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5
1.87	9.60	28.57	-	-	101.	96.24	96.24	9.472	9.472	236.3	225.7	1.6.5.0	1.4.5.0	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5
2.72	14.03	41.57	-	-	143.4	136.9	75.320	9.472	9.472	236.3	225.7	1.6.5.0	1.4.5.0	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5	2.1.5
3.18	21.57	63.87																												



Measurements of Inductance. July 18th 1914

No.	Obs.	No. of Coil	Res. obs.	Leads or insertion	Res. of coil.	Bridge	Condenser	Inductance with Shunt	Shunt correct.	Turns Contd.	Inds. inserted	Inds. of coil
1		Without core	5.955	0.026	262 5.929	1000/10	4.4.05	26.23				
2			8.641	Inductor 50		-	3.535	30.55	0.140			
3			122.15	50 + 100		1000/100	0.258	31.51	0.013		0.8	30.7
4		Core inserted	122.45	"		"	3.093	377.75	"		"	377.
5			92.	+ 50		"	4.118	378.9	0.015			378.
6			91.99	"		-	4.268	392.6	0.038			391.8
7			82.0	"		-	4.858	394.2	0.047			393.4
8		Inductor 50	153.56	0.086	153.47	"	0.593	91.04				
9		" 165.	114.926	"	114.84	-	0.055	0.82				
10		"	114.94	"	114.95	100/10	0.550	0.82				
11		" 50	1.559	"	1.664	"	0.10	0.0152				
12		"	1.557	"	1.671	1000/10	0.01	0.0152				
13		Coil # 17	5.192	1.562	3.630	1000/10	3.475	18.04	~~0.017~~		0.015	18.025
14			7.187	3.562	3.625	"	2.50	17.975	"		"	17.960
15			3.718	0.086	3.632	"	4.85	17.62			0	
16		Core inserted	118.56	Inductor 50	103.6	1000/100	1.83	217.0	0.013		0.82	216.2
17			118.56	-	-	-	1.87	221.7	0.044		"	220.9
18			105.16	" 50	"	"	2.105	221.4	0.05		0.02	221.2
19		Coil # 16	2.074	0.086	1.988	1000/10	4.815	9.988			"	9.988
20			66.79	64.79	-	1000/100	1.685	112.5	0.018		0.82	111.7
21			66.79	-	.	-	1.735	115.9	0.070		"	115.1

The results may be summarised thus:—

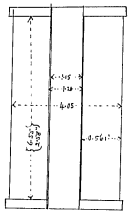
Taking Coil #16 as standard, and unity

The inductance of #17 is 1.8 without core 1.936 with core $n^2 = 1.904$

- - - #19 - 3.06 - - 3.338 - - 3.367

Breaking stress of Fine Wires. July 18th

A platinum iridium wire enamelled 0.005 (0.002") was found to just break with 150 grammes weight. A soft copper wire of approximately the same diameter did not support more than 80g.



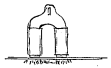
$2t = 0.009'' = .01778$ say 0.018

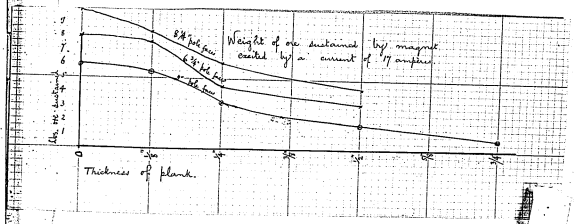
Arm $\{$ $4.05 = 12.8325$
" $1.20 = 1.1310$
$\overline{11.7015}$ $\times 6.55 = 76.96$ cu.

$r = 9''$

$\frac{R}{r} = 8.62 \quad \sqrt{8.62} = 2.94$

4.05
1.20
5.25
$2.625 = 5.246$ cu. $= 3.247'' = 0.27'$





Winding Calculation 19th July 1892.

$$d = -t + \sqrt{t^2 + 1.535 \times 10^{-3} \sqrt{\frac{L}{T}}}$$

say 0.018

$t = 0.009$

$t^2 = 0.81 \times 10^{-4}$

$0.081 \times 10^{-2} + 4.512 \times 10^{-3}$

55 × 76.96 ec

$\sqrt{4.593 \times 10^{-3}}$

6.777×10^{-2}

2.94

$= 0.06777 - 0.009 = 0.0587$ mm. $= 0.0231$" correct to 0.030" #28 Brit.

$2.58 \div 0.030 = 86.0$ turns per layer

$0.561 \div 0.030 = 18.7$ layers

47" = 0.27'

Say $85 \times 18 = 1620$ turns $\times 0.27 = 440'$ @ $0.02028 = 8.88$

$2.58 \div 0.030 = 86.0$ Say 82 turns × 19 = 1558 turns × 0.27 = 421' × 0.02028 = 8.50 ω

$0.561 \div 0.030 = 18.7$

82 turns + 20 layers (2.58" × 0.6") completely filling spool = 1640 turns × 0.275 = 451'.

451 × 0.0202 = 9.1 ω

Best result 1558 turns in 19 layers of 82 turns each #23 B.S. wire 0.0226" correct to 0.030" single cotton. Length 421' Weight 0.65 lb. Resistance @ 20° C. 8.50 ω

Two such spools will make a magnet holding 842' 1.3 lbs, 17 ω #23 B.S.
Actual measurement 842' 1.3 lbs 17.12 ω @ 23 °C.

Experiment on the Lifting Power of Ore-Milling Magnets

One of the regular ore milling magnets was suspended above the floor, and wooden boards of different thickness laid against the pole face. Bruised ore was then thrown up against the board and the quantity that would stick remain, weighed.

The curve shews the results.

The upper curve shews the effect produced by laying cast iron circular plates about 1/2" thick on the poles so as to increase the effective polar area.

Physiological Experiment July 26th 92

Dr Peterson present.

A bundle of wire cotton covered copper wire was suspended on a wooden frame, so as to permit the introduction of the head into the centre of the coil. The internal diam. was about 25 the ext. diam. about 40 and the height about 30. The mass about 70 kilos. The res. of this coil was 10.1 ω and its inductance

210.1×10^{-9} ohm $\times 3.269^2 = 0.7286$ H

The current sent through this coil was about 1.85 amp. from 1200 volts mains. $E = pLi = 890 \times 0.729 \times 1.85 = 1200$.

No sensation was perceptible to a person whose head was in the coil, when the current was started, interrupted, or maintained.

A bulb lamp was shut up in the space between the poles of a #3 Edison cast iron S.C. Motor from 18-20 to 23 ω. The field was excited during that time. No change was indicated by the dop behavior, due to the field.

Analysis of Diagrams taken from the E.G.E.
Engine 2 x 200 KW at Elm St. on the 13th July, by W Phelps.

Stroke 30". R.p.m. $\frac{125}{180}$ R.p.s. $\frac{3.083}{1.717}$

Diams. of H.P. cylinder 16.25", Area 205 sq. in. Above 194 sq. in. below.
" " I.P. " 23.875" 447 436
" " L.P. " 38.5" 1164 1153.

Mean Pressure x R.p.s. x Area x 2.5 x 1.356 = Watts

Area x 2.5 x 1.356 for H.P. Upper 695 I.P. Upper 1595 L.P. Upper 3946
H.P. Lower 657.6 Lower 1478 Lower 3909

Engine Friction. 125 r.p.m. 2.083 r.p.s.

M.P.	H.P.	Upper	= 1.84 lbs	= 3.832 =	26,640	M.P.H.	Lower	0.29 lbs = 0.604 =	397
" "	I.P.	"	= 8.16 "	= 16.99 =	28,730			9.42 " = 19.62 =	29,000
" "	L.P.	"	= 1.12 "	= 2.333 =	9206			1.56 " = 3.249 =	12,700
					61,576				42,097
									61,576

Total power exerted 103,673 watts

Load 2600 amp x 124 volts = 322,500 Watts electrical 113 R.p.m. - 1.883 r.p.s.

M.P.	H.P.	Upper	= 58.6 lbs	= 110.3 =	76,620	Lower	= 47.9 lbs	= 90.2	59,330 135,970
	I.P.	"	= 28.1 "	= 52.9 =	80,160		= 28.25 "	= 53.20	78,620 159,780
	L.P.	"	= 6.49 "	= 12.22 =	48,220		= 8.29	= 15.61	61,030 109,250
					205,020				198,980 404,000
									205,020
								Total activity	404,000

Nett efficiency of engine and dynamos 79.82 %

Load 3100 amp x 125.5 volts = 389,000 Watts electrical. 102 R.p.m. 1.7 R.p.s.

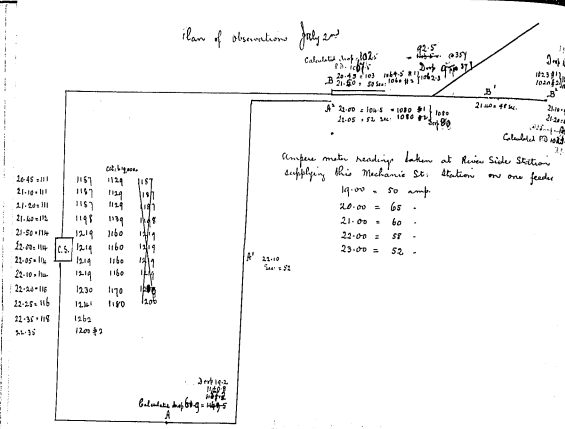
M.P.	H.P.	Upper	= 69.2 lbs	= 117.6 =	81,740	Lower	= 61.1 lbs	= 103.85 =	68,300 150,040
	I.P.	"	= 32.2 "	= 54.73 =	82,910		= 33.4 "	= 56.78 =	83,920 166,830
	L.P.	"	= 10.0 "	= 17.0 =	67,080		= 11.6 "	= 19.72 =	77,100 144,180
					231,730				229,320 461,050
									231,730
								Total activity	460,050

Nett efficiency of engine and dynamos 84.38 %.

Measurements with the Large Experimental Electromagnet fitted with conical pole.

Each limit has 2728 turns of #19 B.W.G. S.C.C. Res: cold 26.27 ω.
With the small exploring, mounted on a wooden handle, and whose total equivalent area is 79 sq. cms, the throw was 20 divs. at the polar distance employed with the frog in the experiments recorded on p. 90. The total flux was therefore $\frac{2.0 \times 10^{8} \times 5.35 \times 10^{11}}{79} = 1354$
On closing up the poles to the distance employed with the dilated epithelium, the throw was 70 divs = 4740.

Plan of observations July 2nd



20.45 = 111	115.7	112.9	115.7
21.00 = 111	115.7	112.9	115.7
21.00 = 111	115.7	112.9	115.7
21.15 = 112	118.5	113.9	118.5
21.50 = 114	121.9	116.0	121.9
22.00 = 114	121.9	116.0	121.9
22.05 = 114	121.9	116.0	121.9
22.10 = 114	121.9	116.0	121.9
22.20 = 115	123.0	117.0	123.0
22.25 = 115	123.0	117.0	123.0
22.35 = 115	123.0		
22.35	123.0		

Amperes meter readings taken at Rivington Street Station supplying this Mechanic St. Station on one feeder

19.00 = 50 amp.
20.00 = 65 "
21.00 = 60 "
22.00 = 58 "
23.00 = 52 "

At A 111.5 @ 21.20 = 111.5 × 112/115

Res. of #4 BS. = 2.473×10^{-4} ω per foot, including return wire 4.946×10^{-4} per ft.

Assuming that the two feeding wires are parallel and 2 feet apart, their inductance per cm. of loop = $4 \log_e \frac{61}{0.26} + \frac{1}{4} = 14.4 \log_e 235 = 22.54$ = loop 2 amp

The resistance per foot of the loop = 4.946×10^{-4}

$p = 880$ $pl = 612.8 \times 10^{-6}$ $\frac{pl}{r} = \frac{612.8 \times 10^{-6}}{4.946 \times 10^{-4}} = 1.239$ $\left(\frac{pl}{r}\right)^2 = 1.5351$

$\sqrt{1+\left(\frac{pl}{r}\right)^2} = \sqrt{2.5351} = 1.592$

$\therefore c = 1.592$ or

For feeder B cr = 51.9 c = 82.6 Observed c = 92.5

A cr = 12.8 c = 20.4 " " = 19.2

Epitome of Measurements made on the 2nd and 9th July by Messrs Hammer, Lanman, & Latimer in Newark City Alternating system.

The currents supplying the two feeders A + B on the 2nd July were not separately observed, but their sum was observed, and is stated on the opposite page at hourly intervals from 19 to 23 oc.

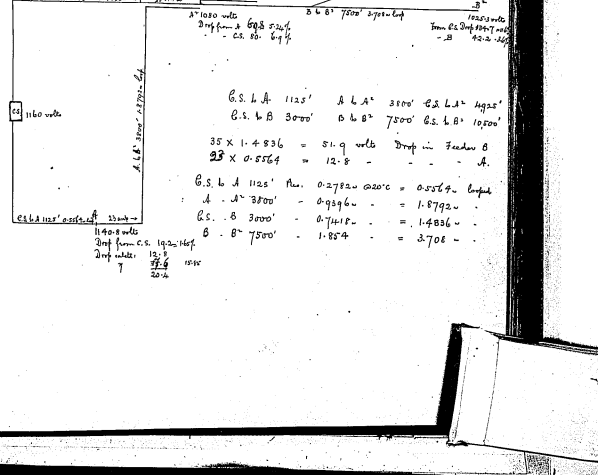
On the 9th July, readings were taken of the currents on the two feeders as follows:—

	20 oc.	20.15	20.30	20.45	21.0	21.15	21.30	21.45	22.0	Means
A	29	29	29	29	29	29	29	29	29	29
B	44	44	43	44	45	44	44	44	44	44
A+B	73	73	72	73	74	73	73	73	73	73.

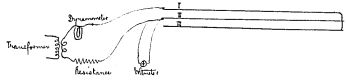
If we assume that this proportion was maintained the week previous the current in A + B would be on the 2nd July.

At	19 oc.	A+B 50	A 19.9	B 30.1
	20	65	25.8	39.2
	21	60	23.8	36.2
	22	58	23.0	35.0
	23	52	20.7	31.3
		285	113.2	171.8

At 22.35 p.m. the voltmeter at the bus bar showed 1262 volts when that used on the line #2 showed 1200. Since #1 and 2 agree, and the resistance of #2 was found to be ~~1000~~ short-circuited to the extent of 1000 ω on return to the laboratory, which would just make up the discrepancy, it is reasonable to suppose that all the readings were affected in this proportion. The following are the computed values of P.D. and current all reduced to 22.35 p.m.



$14.86 \times 6.2832 = 889.8$ cy per sec. f



$\left(1+\frac{L\omega}{r}\right) = 2.247$ $\quad \frac{L\omega}{r} = 1.247$ $\quad \frac{L}{r} = 1.117$ $\quad \frac{l}{r} = 1.255 \times 10^{-3}$ apparent $l = 2.644$ mh.

$\left(1+\frac{L\omega}{r}\right) = 2.088$ $\quad \frac{L\omega}{r} = 1.088$ $\quad \frac{L}{r} = 1.043$ $\quad \frac{l}{r} = 1.172 \times 10^{-3}$ app $\frac{l}{r} = 2.383$ mh.

$\left(1+\frac{L\omega}{r}\right) = 2.152$ $\quad \frac{L\omega}{r} = 1.152$ $\quad \frac{L}{r} = 1.073$ $\quad \frac{l}{r} = 1.206 \times 10^{-3}$ app $\frac{l}{r} = 2.456$ mh.

233
1·0777

74·73
2·491

4000' = 12192 cms. so that l per cm. of loop = 20.43

Neglecting static capacity $\quad 1 + \log_e \frac{L}{r} = 20.43$

$\log_e \frac{L}{r} = 19.43/4 = 4.858$

$\frac{L}{r} = 129$

$r = 0.2575$

$h = 33.26 = 1.091' = 13.092''$

(100)

Measurement of Inductance and the fall of pressure with alternating current in overhead wires.

July 22nd 1892.

Three ⌀ 6 B.W.G. wires 0.203" diam. 0.2575 cms rad. 4000' long (3900' by roads) the wire cross sectd. together at the box on the last pole. The res. by bridge was observed, as also the apparent inductance, from the Galv. room:

I + II	1000 ~	2.911 ω	0.794 hd.	= 2.187 ω	0.895 ⌀	app. ind. = 2.695 millihenry.
I + III	-	2.931 ω		= 2.137	0.968 ⌀	- - 2.837 - -
II + III	-	2.886 ω		= 2.092 ω	0.948 ⌀	- - 2.736 - -
hnds. b E.R.	-	0.794			0.25	- - 0.199

Apparent resistance of loop

- - -	I + II	2.117 ω	2.406 mh.
- - -	I + III	2.137 ω	2.638 -
- - -	II + III	2.092 ω	2.537 -
		6.346	15.81
		3.173	2.527 mean

Insulation of all 3 wires together 10,000 ω abs.

Res. of ⌀ I	1.081 ω
- - ⌀ 2	1.036 ω
- - ⌀ 3	1.066 ω

Temp. of Bridge 26.7°C 2.740×10^{-4} per ohm
- - air in shade 29°C 2.59 . . .
Time Weather + warm. 2.615 ω . . .

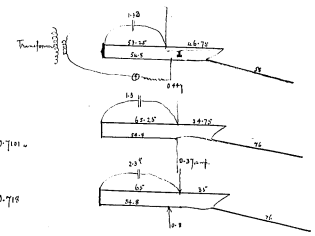
Set up a Westinghouse 30 ℓ transformer in dynamo-room, operated from the alternator. This was connected thro a dynamometer to the overhead wires and the resistance board. The pressure on the line was measured by two Weston A.C. voltmeters, in succession.

The corresponding measurements with continuous currents were also made.

Loop	Dyn.	Γ	Amp.	Volts (P.D. obtained by the difference)	Mean P.D.	Res. by Curve	Dyn.	Γ	Amp	Volts (P.D. obtained by the difference)	Mean	Impedance by curve	Impedance by Volts
I + II	206°	14.35	13.13	I 27.3, II 27.03	27.175	2.070 ω	163.5	12.78	11.70	I 36.4, II 36.25	36.33	3.106	
	264	16.25	14.87	I 30.8, II 30.6	30.7	2.064 ω	175	13.23	12.11	I 37.6, II 37.75	37.68	3.112	
	352.5	18.77	17.17	I 36.0, II 35.8	35.9	2.091 ω	320	17.89	16.37	I 51.0, II 51.0	51.0	3.115	
						2.075 ω						3.111 ω	1.499
II + III	213°	14.59	13.35	I 27.2, II 27.1	27.15	2.034	209	14.46	13.23	I 39, II 38.9	38.95	2.905	
	274	16.55	15.14	I 30.5, II 30.75	30.63	2.023	2205	15.51	14.19	I 41.8, II 41.5	41.65	2.936	
	358°	18.92	17.31	I 35.5, II 35.25	35.38	2.044	332	18.22	16.67	I 49.5, II 49.1	49.3	2.940	
						2.034						2.940 ω	1.464
I + III	209	14.46	13.23	I 27.5, II 27.0	27.25	2.060	212.3	14.57	13.33	I 40.3, II 40.1	40.2	3.016	
	262	16.19	14.82	I 30.8, II 30.5	30.65	2.069	236.0	15.33	14.03	I 42.6, II 42.1	42.35	3.019	
	338.5	18.39	16.83	I 36.8, II 36.5	36.65	2.059	311.0	17.64	16.14	I 49, II 49	49.	3.036	
						2.062						3.024	1.467
												Mean	1.470

The results of these measurements are:-

The mean impedance is 47% greater than the resistance of three loops
- - angle of lag - 47° 8'
- - e.m.f. of inductance is 7% greater than the drop due to r.
- - calculated distance between the wires is 13·1" (33·3 cms)



$59.5 \times 0.02433 \times \frac{34.75}{65.25} = 0.7101\,\omega$

$54.5 \times 0.02433 \times \frac{35}{65} = 0.718$

1.00023 $L\omega$ @ $\overset{28.6}{16.0}$ °c. $\frac{}{11.7} \times 1.02 = 0.351$

log $1.00023 = 0.00012159$
$= 1.00351 = 0.00\cancel{3}\cancel{8}\cancel{1}\cancel{8}\cancel{0}$ $L\omega$ @ 28.6°c.
0.39108829
0.00101113
$0.00768.32 = 1.00146$ Ω @ 28.6 Shunted by $1000\omega = 1.000146$ Ω

log 9889
9966
9951524
0941411
·0010113 1.00233

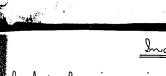
$\frac{2753}{2852} = \frac{96.5}{99.5}$ log $= \frac{2753 \cdot}{2853 \cdot}$ $\frac{143980.62}{4553018}$
$\frac{9585044}{9962927}$
-9995 $\frac{9582117}{200.1997}$
9584114 $9.7322 \times 10^{-2} = 0.09732\,\Omega$ @ 28.6
9.737 0.09737 Ω

log 96·5 $= \frac{9885444}{9995}$
$\frac{9789466}{·0116076}$ 10274 0.10276 Ω @ 24°c

$\frac{2752.7}{2691}$
log 5433·7 3.7350957
log 2752·7 3.4397589
0.2953368
log 0.0973 $\frac{5.9884111}{}$
$\frac{7.2837482}{2.6930746}$ 0.0493.26 Ω

Inductance Measurements.

A loop of iron wire radius 0.027 c.c. & diameter of 0.070. had a length of 5ft 10 cms with the two sides pulled close together.



Res: of slide wire AB 0.222 per cm. platinoid.
AC 0.0243 " manganin
Uniform current by ~~battery~~ alternator. Current in supply main measured. Telephone employed.
EMF used

With 0.3 amp. Res: = 0.1187 ω. Inductance $1.13 \times 53 \times 0.222 \times 1.1187 \times 10^{-6} = 15710 \times 10^{-6}$ Henry
Inductance per cm. of loop = 270 cm.

With current increased to 0.44 amp. Res = 0.1171 ω
Inductance $1.33 \times 53.25 \times 0.222 \times 1.171 \times 10^{-6} = 18.41 \times 10^{-6}$ Henry
Inductance per cm. of loop = 317.4.

Bar iron wire in a loop. the sides of which were separated by glass. Radius of wire 0.0295 length of loop 76. distance between wires 0.4.

With 0.37 amp applied. Res = 0.7101 ω Inductance $1.3 \times 65.25 \times 0.222 \times 0.7101 \times 10^{-6} = 13.37 \times 10^{-6}$ Henry
Inductance per cm. of loop = 175.9

With 0.8 amp applied. Res. = 0.7180 Inductance $2.3 \times 65 \times 0.222 \times 0.718 \times 10^{-6} = 23.83 \times 10^{-6}$
Inductance per cm. of loop = 313.5.

The last observation is not very accurate. When the current strength is increased the suppression of the fundamental note is more difficult to observe

Measurement of Standard Resistance.

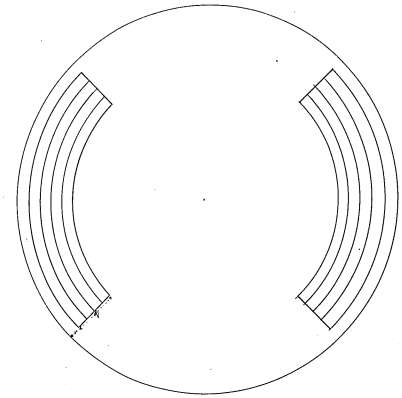
Aug. 2nd 92.

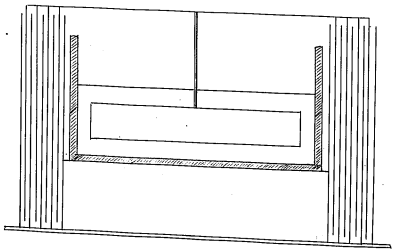
Res. of H.B. Diff. galv. 5506.2 @ 24.2°c. 100/100
7
5505.3
2752.65 ω each coil

Comparison of my standard ohm @ 28.6°c. and spiral 1/10th, in manganin
Bridge arrangement 100 in 995 ω. & galv. = 0.09737 Ω @ 24°c.

Comparison of my standard ohm @ 28.6°c. (1.00146 Ω of loop) and substandard 1/10th ω of manganin in wood. = 0.10276 Ω @ 24°c.

Comparison of grid in series against spiral 1/10th.
2681 ω added to spiral. Res. 0.04932 ω @ 24°c.





Design for a Static Voltmeter to operate on 120 volts.

The fundamental equation is $M\mu = \frac{\Sigma h r V^2}{8\pi d}$ for the moving moment

and $= \frac{Mg\sin\theta}{fl}$ - - restituting

where Σ = the summation of active surfaces

h = - height of each active surface

r = - radius - - - -

V = - emf. in static units

d = - distance between opposing surfaces

g = - gravitation acceleration

f = - distance between threads of lifter

θ = - angle of deviation

M = - mass of suspended system

l = - length of each suspending wire

In order to indicate 100 volts @ 60° deviation, where $\sin\theta = 0.866$ moment of the existing 500-volt meter being 70 dyne-cms, that of 60.62 @ 60°, we may allow half this or 30.0 dyne cms. at 60°.

As shown on the opposite page, there are 16 active surfaces.

$V^2 = 1/9$ @ 100 volts

$d = 0.15$

$8\pi d = 3.771$

$\Sigma h = 16 \times 5.65 = 90.4$

$\therefore h = \frac{30 \times 3.771}{90.4 \times 0.1111} = 11.26.$

Allowing a moment of 20 dyne cms. @ 60°, we have

$h = 7.5$

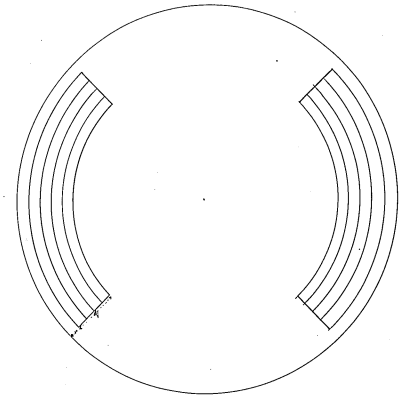
accompanying scale shows the relative advantage of employing a lifter panel with a simpler suspension. The last 16% of the reading equal 1.64 times as much length of scale as with simpler suspension. With mean radius of 5.45 cms, the $\frac{\text{circ.}}{2} = 8.56$ cms. The surface of vanes will be $8.56 \times 8 \times 7.8 = 534.2$ sq. cms. Say 600 sq. cms. in all. Mass of this will be 60.97 gms. The total mass say 55 gms.

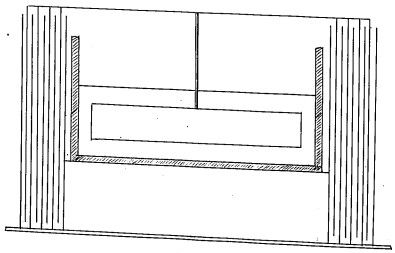
$$f^2 = \frac{4\,l\,\mu}{Mg\sin\theta}$$

$$= \frac{4 \times 13 \times 20}{55 \times 981 \times 0.5} = \frac{104 \times 10^2}{2.697 \times 10^4} = 3.855 \times 10^{-3}$$

$$f = 0.1963 \quad \text{say } 0.2$$

As constructed the outside distances $f = 1.80$ each wall 0.093. The width of grooves 0.346. Thickness of vanes 0.032. Clearances 0.157. Height of walls 7.55 of vanes 7.575. Mass of suspended system 65.71 g. Distance of 0.3. below vane plate 2.8. Pointer radius 15.6. Mean vane radius 5.6. Suspension wire length between clamps 12.6. Upper distance between wire axes 1.457×10^{-1} Lower 1.918×10^{-1}. geometrical Mean 1.672×10^{-1}





Design for a Static Voltmeter to operate on 120 volts.

The fundamental equation is $M\mu = \frac{\Sigma h r V^2}{8\pi d}$ for the moving moment

and $= \frac{M g f \sin\theta}{l}$ - - restituting -

where Σ = the summation of active surfaces

h = - height of each active surface

r = - radius - - - -

V = - emf. in static units

d = - distance between opposing surfaces

g = - gravitation acceleration

f = - distance between threads of bifilar

θ = - angle of deviation

M = - mass of suspended system

l = - length of each suspending wire

In order to indicate 100 volts @ 60° deviation, where $\sin\theta = 0.866$ the moment of the existing 500-volt meter being 70 dyne-cms, that of at 90° or 60.62 @ 60°, we may allow half this or 30.0 dyne cms. at 60°.

As shown on the opposite page, there are 16 active surfaces.

$V^2 = 1/9$ @ 100 volts

$d = 0.15$

$8\pi d = 3.771$

$\Sigma r = 16 \times 5.65 = 90.4$

$\therefore h = \frac{30 \times 3.771}{90.4 \times 8.1111} = 11.26.$

Allowing a moment of 20 dyne cms. @ 60°, we have

$h = 7.5$

The accompanying scale shews the relative advantage of employing a bifilar as compared with a unifilar suspension. The last 16% of the reading occupy 1.64 times as much length of scale as with unifilar suspension.

With mean radius of 5.45 cms, the $\frac{\text{circ.}}{8}$ = 8.56 cms. The surface of the vanes will be $8.56 \times 8 \times 7.5 = 5342.2$ sq. cms. Say 600 sq. cms. in all. The mass of this will be 60.47 gms. The total mass say 55 gms.

$$f^2 = \frac{4 I \mu}{M g \sin\theta}$$

$$= \frac{4 \times 13 \times 20}{55 \times 981 \times 0.5} = \frac{10.4 \times 10^4}{2.698 \times 10^4} = 3.855 \times 10^{-1}$$

$f = 0.1963$ say 0.2

As constructed the outside distances of = 1.80 each walls 0.043. The width of grooves 0.346. Thickness of vanes 0.032. Clearance 0.157. Height of walls 7.55 of vanes 7.575. Mass of suspended system 65.71 g. Distance of 0.3. below vane plate 2.8. Pointer radius 15.6. Mean vane radius 5.6. Suspension wire length between clamps 12.6. Upper distance between wire axes 1.457×10^{-1} lower 1.918×10^{-1}. geometrical Mean 1.672×10^{-1}

log 9.899 = 9.995524
" 9.866 = 9.995411
1.00233 = 0.000113

$\frac{2799.7}{2800.4}$ $\frac{2799.7}{3590.4}$

$\frac{9.8216 \times 3590.4}{2800.4 \times 1.00233} = 0.0012256$

0.021 × 3.0 = 0.63%

$9.76 \times 10^{-3} \times 1.0063$ log 9.76 = 3.989445
− 1.0063 = 0.00273
9.8216 = 3.992218

log 9.8216 = − 3.992218
" 1.00233 = 0.000101
1.799 = −3.992117
log 3590.4 = 3.555043
2546313
− 2800.4 = 447220
1.2563 ~~ohm~~ 2099093
0.00273
1.2495 @ 60°C 2.096363

(103)

Comparison of Grid Resistance with the 0.01ω Switch standard. July 27th

Res. of H.B. Cylind. coils, properly differentiated (10ω added to each coil) 759.94ω by Bridge @ 29°C
Current of about 6 amp. passed through grid (in parallel) & 0.01ω coil in series.
Balance effected by 790ω added to grid. Leads each 0.7ω
Res. of grid @ 30°C = 0.0012256 Ω

Test of Carrying Capacity of conductor Siemens Cable Sample from Schenectady July 27th 92.

This is a 30ft length of lead covered siemens cable, jute core & 6 B.W.G. intended for pressures up to 3000 volts.

The length between soldered pressure wires at end of jute = 918.5 = 30.15' = 361.6" / 30.1.6

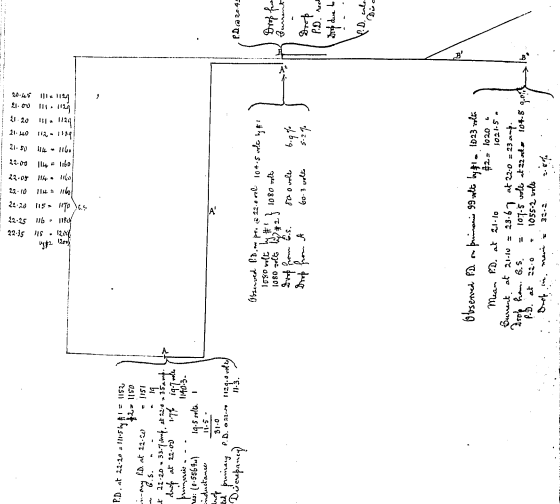
- diameter of conductor 0.425 = 0.1673" — Area 0.14186
- " over jute 1.022 = 0.4023" — Circ 1.3352
- thickness of jute 0.298 = 0.1173"
- diameter of lead cable 1.426 = 0.5615"
- thickness of lead cover 0.064 = 0.0252"
- Mass of sample 7.37 lb = 16.25 lb
- " per cm. 8.025 gms
- " " foot = 0.5392 lb.
- " " mile of 5280' = 2847 lb.

The cable was laid out straight on the stone floor, in circuit with the grid in multiple, and the following measurements made:—

Temp. Platin.	C°	Watts per cm.	Elevation of Temp											
17.5														
20														
21.5	772.8+	0.0100	17°C.											
25°														
22°														
22°	2352.3	0.0311												
22°		0.0311	23°C.											
30°														
31°														
32°	4569.8													
33°		0.0625	33°C.											
33.5														
34.5														
36°	7106.5	0.0949	39.5°C											
36.5														
36.5	6272.7	0.0839	36°C. 25°C when shunt											

Determination of Matthiessen's Temp: Coeff: in Copper from 40° to 100°C.

t	t'°C	t^2	0.003987t	1-0.003987t	0.00000 gong t^2	C_t	R_t/R_0	Exp. Eq.
	40	1.6×10³	0.15850	0.84520	0.00[illegible]413	0.85963	1.1633	
	41	1.681	0.15867	0.84133	0.01[illegible]14	0.85647	1.1675	0.0054
	42	1.764	0.16284	0.83716	0.01589	0.85335	1.1718	0.0057
	43	1.849	0.16701	0.83299	0.01666	0.85025	1.1761	0.0057
	44	1.936	0.17028	0.82972	0.01744	0.84716	1.1804	
	45	2.025	0.17412	0.82588	0.01824	0.84409	1.1847	
	46	2.116	0.17802	0.82198	0.01906	0.84104	1.1890	
	47	2.209	0.18189	0.81811	0.01990	0.83801	1.1933	
	48	2.304	0.18576	0.81424	0.02076	0.83500	1.1976	
	49	2.401	0.19163	0.81037	0.02163	0.83200	1.2019	
	50	2.500	0.19350	0.80650	0.02252	0.82902	1.2062	
	51	2.601	0.19737	0.80263	0.02343	0.82606	1.2106	
	52	2.704	0.20124	0.79876	0.02436	0.82312	1.2149	
	53	2.809	0.20511	0.79489	0.02531	0.82020	1.2192	
	54	2.916	0.20898	0.79102	0.02627	0.81729	1.2235	
	55	3.025	0.21285	0.78715	0.02725	0.81440	1.2279	
	56	3.136	0.21672	0.78328	0.02825	0.81153	1.2322	
	57	3.249	0.22059	0.77941	0.02927	0.80868	1.2365	
	58	3.364	0.22446	0.77554	0.03030	0.80584	1.2409	
	59	3.481	0.22833	0.77167	0.03136	0.80303	1.2453	
	60	3.60	0.23220	0.76780	0.03243	0.80023	1.2497	
	61	3.721	0.23607	0.76393	0.03352	0.79745	1.2540	
	62	3.844	0.23994	0.76006	0.03464	0.79470	1.2583	
	63	3.969	0.24381	0.75619	0.03576	0.79195	1.2627	
	64	4.096	0.24768	0.75232	0.03690	0.78922	1.2671	
	65	4.225	0.25155	0.74845	0.03806	0.78651	1.2715	
	66	4.356	0.25542	0.74458	0.03924	0.78382	1.2758	
	67	4.489	0.25929	0.74071	0.04044	0.78115	1.2801	
	68	4.624	0.26316	0.73684	0.04166	0.77850	1.2845	
	69	4.761	0.26703	0.73297	0.04289	0.77586	1.2889	
	70	4.900	0.27090	0.72910	0.04414	0.77324	1.2933	
	71	5.041	0.27477	0.72523	0.04541	0.77064	1.2976	
	72	5.184	0.27864	0.72136	0.04670	0.76806	1.3020	
	73	5.329	0.28251	0.71749	0.04801	0.76550	1.3063	
	74	5.476	0.28638	0.71362	0.04933	0.76295	1.3107	
	75	5.625	0.29025	0.70975	0.05067	0.76042	1.3151	
	76	5.776	0.29412	0.70588	0.05203	0.75791	1.3194	
	77	5.929	0.29799	0.70201	0.05341	0.75542	1.3238	
	78	6.084	0.30186	0.69814	0.05481	0.75295	1.3281	
	79	6.241	0.30573	0.69427	0.05622	0.75049	1.3324	
	80	6.40	0.30960	0.69040	0.05766	0.74806	1.3368	
	81	6.561	0.31347	0.68653	0.05911	0.74564	1.3412	
	82	6.724	0.31734	0.68266	0.06058	0.74324	1.3456	
	83	6.889	0.32121	0.67879	0.06206	0.74085	1.3498	
	84	7.056	0.32508	0.67492	0.06356	0.73848	1.3541	
	85	7.225	0.32895	0.67105	0.06509	0.73614	1.3584	
	86	7.396	0.33282	0.66718	0.06663	0.73381	1.3627	
	87	7.569	0.33669	0.66331	0.06819	0.73150	1.3671	
	88	7.744	0.34056	0.65944	0.06976	0.72920	1.3714	
	89	7.921	0.34443	0.65557	0.07136	0.72693	1.3757	
	90	8.100	0.34830	0.65170	0.07297	0.72467	1.3799	
	91	8.281	0.35217	0.64783	0.07460	0.72243	1.3842	
	92	8.464	0.35604	0.64396	0.07625	0.72021	1.3885	
	93	8.649	0.35991	0.64009	0.07792	0.71801	1.3928	
	94	8.836	0.36378	0.63622	0.07960	0.71582	1.3970	
	95	9.025	0.36765	0.63235	0.08131	0.71366	1.4012	
	96	9.216	0.37152	0.62848	0.08302	0.71150	1.4055	
	97	9.409	0.37539	0.62461	0.08476	0.70937	1.4097	
	98	9.604	0.37926	0.62074	0.08652	0.70726	1.4139	
	99	9.801	0.38313	0.61687	0.08829	0.70516	1.4181	
	100	10.0	0.38700	0.61300	0.09009	0.70309	1.4223	



1.4936 × 3.592 = 2.362 ω
0.5567 × 1.592 = 0.8868

0.8868 ω = 19.7 " = 22.24
58 − 22.24 = 35.76 Amp. Ex. 24 Volts. 72.6 24 1.5
50 × 2.362 = 70.24 24 1.5.
28 × 0.8868 = 24.8 − 5.1
70.6 − 24.8 = 30.73 amp.
58 − 30.7 = 27.3 × 0.8868 = 24.2
1.42
4.5 volts.

The distribution of current best according with the figures = 30¾ amp along B
27¼ " " A
with 4.5 volts too high a pressure at A in consequence, that at B ok.

Epitome of Measurements made on the 27th and 9th July

by Messrs Hammer, Lamman, + Latimer, in Newark City alternating system.

The currents assumed on page 99, have been found to be misdirected, the greater, actually) passed along A, and the lesser along B. With this modification the case stands as follows:-

Winding for an alternating current motor Meter

that shall have the same dimensions as that already constructed and whose specification appears on page 76, but which shall have more turns in order to start on one ampere.

Aug. 27th

The starting current of the present model being 3.5 amp, we require twice as many turns on both field and armatures.

The two external coils can each be 4 layers of 9 turns # 15 B.W.G. = 36 turns, 0.072" c.c.c. to 0.080", instead of 3 layers of 6 turns = 18 turns # 12 B.W.G. The total length of wire will be 72 × 1.5 = 108' = 1.5 lbs and 0.216 ω

The four internal coils can each be 4 layers of 12 turns = 48 turns or 48' # 19 B.W.G. 0.042" s.c.c. to 0.050". The total length of wire will be 192' = 1.03 lbs and $\frac{1.123}{4}$ = 0.281 ω. Total Res: 0.5 ω

Drop 5 volts at 10 amp. and full = $\frac{48 \times 36}{27 \times 19}$ = 3.55 times as great.

Test of this meter on completion 24th August

Lamps	Block	Amp.	R.p.m.	R.p.m./amp		
3	0.275	1.419	7.8	5.5		
4	0.358	1.847	15.5	8.39		
5	0.440	2.271	21.0	9.25		
6	0.532	2.745	26.7	9.73		
8	0.718	3.706	37.5	10.14		
10	0.850	4.386	47	10.72		
12	1.025	5.289	56	10.59		
14	1.120	5.831	63	10.8		
16	1.310	6.760	72	10.65		
18	1.450	7.482	78.5	10.49		
20	1.620	8.358	86	10.29		
22	1.760	9.080	95.5	10.52		
24	1.980	10.22	107	10.47		
2			(only starts)			

Res. 0.50 ω @ 20°C.
Inductance 0.86 to 0.92 mh. according to position of armature.
Mean 0.74 mh. Mean impedance @ 140 ω 0.83 ω.

$\log 9.8216$

$$\frac{R}{H}\int \frac{\sin\theta}{\cos\theta}\,d\theta = \frac{\Delta V}{H}$$

$$\frac{2\pi}{R}\log\frac{R}{r} = \Delta V$$

2839.6
8.45
37846
2839.6
$\log 9.7799 =$

5780085
4553419
1247666
9911818
1159484

1.306×10^{-2}

1306
1287
2563
1232

	Res. of coil (Ω)	Res. added for balance	Ratio	Standard Res. at temp.	Res. of coil at temp.	Res. per cm.	Resistivity (Ω 0°C.)	$\frac{R}{r}$	Temp. fusion		P.D. mv.
20.40					1.193×10^{-2}						
21.00				0.01282×10^{-2}	1.246	1.299×10^{-2}	1631 Ω	1.0745			0.072
21.20	1 50	2823.7	210	$\frac{1.0745}{1}$							
21.40	2 11.09		205	1.0726	1.195	1.301	97.7 μ cm.	1.002	0.5°	29.55	0.337
21.50											
22.00	3 15.30		205	1.0726	1.195	1.301		1.002	0.5	29.50	0.350
22.05											
22.10	4 .31		195	1.0694	1.199	1.305		1.005	1.2°	30.2	0.550
22.20	5 .43		192	1.0680	1.200	1.306		1.006	1.5°	30.5	0.555
22.25											
22.35	6 .55		192	1.0680	1.200	1.306		1.006	1.5°	30.5	0.550
	7 16.00		165	1.0585	1.211	1.318		1.015	4°	31.	0.575
	8 .10		155	1.0549	1.215	1.323		1.018	4.6°	32.6	0.526
	9 .20		155	1.0549	1.215	1.323		1.018	4.6	32.6	0.425
	10 .25		120	1.0425	1.230	1.339		1.031	8°	37	1.078
	11 .35		115	1.0407	1.232	1.341		1.033	8.5°	37.5	1.025
	12 .40		50	1.0177	1.260	1.372		1.056	12.3°	42.3	1.255
	13 .50		60	1.0212	1.254	1.365		1.051	13°	42	1.230
	14 17.00		32	1.0113	1.267	1.379		1.062	15.5°	44.5	1.340
	15 .10		25	1.00885	1.271	1.384		1.066	16.7°	45.7	1.378

The thermal resistance $= \int \frac{d\rho}{2\pi} = \frac{\rho}{2\pi}\log_e\frac{R}{r}$

Heat transfer in therms per sec. $= \frac{2\pi(V_1 - V_2)}{\rho \log_e \frac{R}{r}}$

$\therefore \rho = \frac{2\pi(V_1 - V_2)}{H \log_e \frac{R}{r}}$

$\log_e \frac{R}{r} = 0.87755$

$\frac{2\pi}{\log_e \frac{R}{r}} = 7.16.$

$R = \frac{H \log_e \frac{R}{r}}{(V_1 - V_2)\,2\pi}$

R. (a) $\rho = 7.50 = 104.75$

$\log 2.405 = 0.3911151$
$\log .3911151 = -1.5810560$
0.3622187
-1.9432717

0.87755

Curve. Representing the transformation characteristics of the 6 ft. 6 in. thermocouple with heated junction and in water. The black curve for heat side, and cold in water. I. dotted. Black. Curve represent characteristics for varying current. Right.

STANDARD CROSS SECTION. 10 to 1 inch.

Carrying Capacity of Siemens Cable contd.

Placed the length of cable, whose test in air appears on page 103, in an iron pipe 880 cms long, 3·3 cms (1·3") inside diam: and 4·127 (1·625") outside diameter with short right angles at each end. This pipe was kept filled with flowing water. 7 cms. of cable projected above the water at one end, and 20 cms at the other, measured from the water's edge to the pressure-wire soldering. The length of cable immersed in water was thus 891·5 cms. The rate of flow of the water was 47 c.c. per sec. through the tube during the test.

Current thro. wire	Temp. of water	Temp. above water	C^2	Watts per linear cm.	Temp. of air	Thermo per linear cm.	$\frac{2\pi}{\Pi \log \rho}$	ρ cms. per sec.	K.
5·62	29°C.	0	31·58	4.102×10^{-4}	32°C.	0.9768×10^{-5}			
26·29		0·5	691·2	8.992×10^{-3}		2.141×10^{-5}			
27·31	28/28·5	2·3	745·84	9·702 "		2·310 "			
42·92	28/28·7	2·4	1842	0·02403		0·005721.			
42·92	~~28·4/29·5~~ 29/6	1·9	1842	0·02406	31°C.	0·005729	1252	2378	4.205×10^{-4}
42·92	28·8	1·7	1842	0·02406		0·005729.	1252	2128	4.699×10^{-4}
63·77	28·8/29·2	4·0	4066·7	0·05360	31·5°C.	0·01276	561·2	2245	$4.4554 \times$ -
64·44	29·1	4·5	4152·5	0·05493		0·01308	547·3	2463	4·060 -
64·44	29·2	4·4	4152·5	0·05493		0·01308	547·3	2408	4·153 -
84·10	29·0/29·5	4·3	7072·8	0·0947	32°C	0·02255	317·5	2445	4·090 -
84·66	29·5	8·0	7167·3	0·0961		0·02288	312·9	2503	3·995 -
97·92	29·0/29·6	9·7	13·6	9584·4	32°C	0·02131	228·7	3110	3·215 -
95·95		29·4	13·6	9206·4		0·02993	239·2	3253	3·074 -
106·10	28·6/29·6	29·1	15·7	11236.	30·5	0·03688	194·2	3049	3·280
107·5		29·1	16·6	11550.		0·03807	188·1	3122	3·203.

3·383 @ 28°C. = 14·339 $\times 10^{-5}$ @ 0°C. = 1597

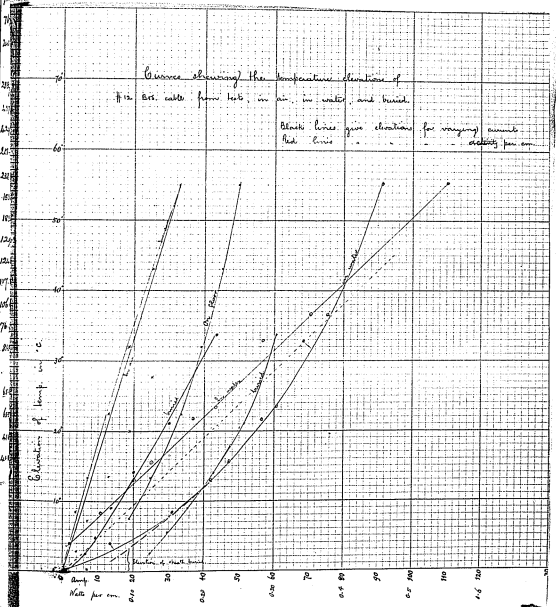
No. of Obs.	Time	Res. of G. coils	Res. added for balance	L	Ratio	Res. of Sol. @ limit	Res. of wire	Res. per cm.	Resistivity @ 0°C	$\frac{R}{r}$	Temp. of coils
1	15.45	2842	300	cm	1.0156	0.0143	0.014433	5.323 $\times 10^{-5}$ = 5.357	1597	1.1128	28°
2	.55		350		1.1123		0.014490	5.387	= 99.6% cond.	1.1136	28.3
3	.57		40		1.0141		0.04999	5.455		1.1275	30.1
4	16.00		47		1.0165		0.05006	5.468		1.1302	32.2
5	.07		50		1.0176		0.05016	5.475		1.1317	32.5
6	.10		90		1.0317		0.05086	5.551		1.1473	36.2
7	.16		101		1.0355		0.05105	5.571		1.1516	37.2
8	.20		162		1.0570		0.05210	5.686		1.1753	42.5
9	.29		150		1.0528		0.05190	5.664		1.1710	41.9
10	.40		182		1.0640		0.05245	5.724		1.1832	44.7
11	.42		178		1.0626		0.05237	5.716		1.1815	44.2
12	.44		220		1.0774		0.05311	5.797		1.1984	48.9
13	.50		240		1.0844		0.05346	5.835		1.206	50.0
14	.51		265		1.0932		0.05390	5.881		1.215	52.0
15	17.03		260		1.0915		0.05381	5.873		1.2114	51.7
16	.15		350		1.123		0.05536	6.041		1.249	59.9
17	.24		369		1.130		0.05570	6.079		1.2567	60.7
18	.25		410		1.1444		0.05640	6.155		1.2722	65.2
19	.37		412		1.145		0.05645	6.160		1.2732	65.3
20	40		617		1.217		0.05999	6.546		1.3530	83.7
21	45	2837	620		1.218		0.06004	6.552		1.3543	84.1

$\frac{R}{r} = 0.645$ $\frac{R}{r} = 3.1462$ $\log_{10} = 0.4977843$ $\log. \frac{69794}{22196} = 1.3462$

$d = 0.205$

$\log_e \frac{R}{r} = 1.1462$

$\frac{2\pi}{\log_e \frac{R}{r}} = 5.482$



Carrying Capacity of Siemens Cable contd.

29th July.

The next sample tested was a 20 ft. length of small cable #12 B.&S.

Diam: of conductor		0.205	(0.0808")
Area	"	0.0330	0.0051150"
Circ.	"	0.644	0.253"
Thickness	jute	0.22	0.0866"
Diameter	"	0.645	0.254"
Thickness	lead	0.1144	0.0448"
Diameter	"	0.893	0.3144"

Length between pressure wire, at end of jute 916.3 mm. (360.8")
Length of line 909.
Jute 3.3 at one end 4.0 at other.

This cable was placed in the ~~same~~ iron water pipe described on preceding page, 14 cms. projected above water level to pressure wire at one end, and 15.5 at the other.

Pd. on gauge	C.	Obsd	C.	Gauge C^2	$\sqrt{W}$ ratio per 1 mm.	Temp. water	Temperature	Elevation of temp	Thermo per 1 mm.	ρ	K.
6.365	7.404			54.82	0.00245	for 37.1 p2	316 33.1	0°	0.0007024	—	
6.368	7.464			55.71	0.00300	270/274-271		0.3°	0.0007143	23038	0.0001302
12.624	13.265			175.9	0.00759	288/322 = 286		1.6°	0.002243	3841	
						285		1.7			
12.668	13.449			182.0	0.00764	28.5		4.0	0.002295	9555	
31.536	31.15			970.3	0.0539	290/322 = 296		7.6	0.01283	3249	
31.530	31.03			962.9	0.0536	289		8.4	0.01276	3610	2400 0.0002915
42.172	44.06			1941.3	0.1104	290/322 = 29.0		13.2	0.02628	2753	
42.062	41.52			1748.9	0.0990	289		13.0	0.02358	3622	2390 0.0002460
42.308	46.52			2192.1	0.1255	287	32.7°	16.0	0.02988	2936	
42.308	46.52			2192.1	0.1253	286		15.6	0.02983	2868	2390 0.0008448
52.736	55.5			3080.3	0.1786	290/278 = 28.8		19.5	0.04252	2515	
52.778	56.34			3174.2	0.1852	28.3		21.7	0.04409	2698	2600 0.0002831
62.976	60.36			3643.3	0.1964	288/296 = 28.0		24.0	0.04677	2812	
62.990	60.64			3678.	0.2160	28.4		23.3	0.05143	2487	2600 0.0007774
73.470	76.38			4493.3	0.2493	290/322 = 28.8		33.2	0.07126	2393	
73.370	68.35			4671.7	0.2840	28.8	316° 31.6°	32.9	0.06962	2668	2390 0.0009573
83.730	75.64	14.04	72.44	5722.9	0.3522	290/322 = 28.7		36.5	0.08386	2390	0.0001132
		14.34	74.00			287		36.6			
94.532	91.92	16.20	83.58	8444.3	0.5531	290/322 = 28.7		55.0	0.1317	2290.	
94.520	91.68	16.17	83.42	8405.2	0.5507	287	31°C. 31°	55.3	0.1311	2312	2300 0.0003408

Particulars obtained of damage occasioned by a thunder-storm in a house at Sydney C.D. over electric light wires supplied from an Edison 3-wire system, 10th August 1892.
from evidence collected on the 14th & 15th August.

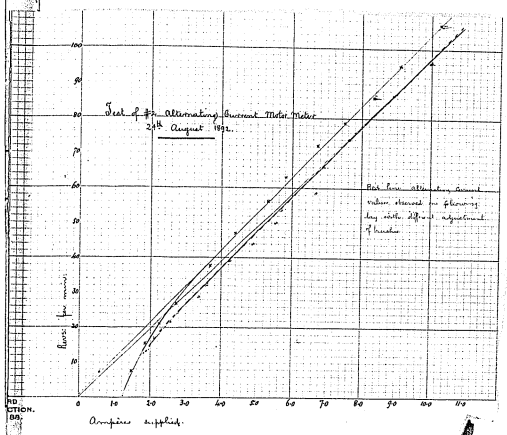
There are two electric light systems in Sydney, the T.H. and the Edison. The former is 2-wire and the latter 3-wire, both low tension continuous currents. The two central stations are close together and their respective pole lines run on opposite sides of nearly all the streets. Fully half a mile from the stations, southwards by the bay shore these pole lines pass the residences of J. Moseley & D. J. Kennelly facing on opposite sides of the road. The former is supplied by the Edison, the latter by the T.H. and the supply wires cross the road in each case. Beyond these houses, the Edison system continues to supply two or three customers up to a distance of half a mile, the T.H. one customer about 1/6th of a mile.

On the 10th Aug. the engines in the stations were started at about 19 00. At 20 00 the load was about 100 amps on each side of the Edison system, the evening dark with a heavy thunderstorm coming up from the S.W. at about 20.05 a thunderclap heard at these two houses followed the flash by an estimated interval of one second so that the discharge was probably within 1200 feet of this locality. At this time there were 8 lamps alight in the Moseley House all on the ground floor. Coincidently with the discharge 16 lamps were broken on this and the first floor. No other damage occurred in the Moseley House, and no damage was reported from any other house in the two systems.

The 3 wires enter the Moseley residence at the back by a first floor window. Through fuse blocks, one of which melted at the time of the accident, they distribute to the various rooms. It was stated that not one of the lamps destroyed was turned on at the time, so that the discharge which broke them must have leaped their switches. The lamps actually alight flashed brightly for a moment, but did not break. The broken lamps were nearly all upon the first floor. At the station, a momentary kick was observed on the negative ammeter by the engineer who stated that he was watching the instrument at the time, and the load fell from 110 to 80 amperes when the pointer next came to rest.

The conclusion suggested was that the lightning may have struck the ground near Moseley's house, and an induced disturbance made itself felt on the Edison system supplying him. Through the + side of the system it either did not pass or passed through the lamps on the ground floor. On the − side the discharge broke the 16 lamps and fused the plug ~~down~~ by the momentary short circuit on the system.

The Edison system has one Wit arrester on each bus bar at the door of the station, and no other lightning protection. The T.H. system has no arresters anywhere.



$25{\cdot}6$
$16{\cdot}3$
$11{\cdot}9$ @ $0{\cdot}03$ = 351 $\quad 1{\cdot}00351$

$\log 1{\cdot}00028 = 0{\cdot}00012159$

$\therefore 1{\cdot}00351 = 0{\cdot}00152170$

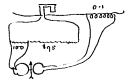
$0{\cdot}00164320 = 1{\cdot}00379$ log v @ 25·6°C.

$0{\cdot}00101113$

$0{\cdot}00063190 = 1{\cdot}001446$ or @ 25·6°C

$\frac{100 \times 2752}{2856} = 96{\cdot}5\,w$ $\quad \frac{96{\cdot}5}{99{\cdot}15} = 0{\cdot}097321$ or @ 26·6°C

$\frac{96{\cdot}5}{99{\cdot}15}$



$\log 100 = 2{\cdot}4649$

$\therefore 2752 = 3{\cdot}4391646484$

$\therefore 2856 = 3{\cdot}4557149485$

$1{\cdot}9824989 = 96{\cdot}4945\,w$

$\therefore 99{\cdot}15 = 2{\cdot}9962937$

$1{\cdot}9952062 = {\cdot}097321$ @ 26·6°C

Test of Alternating Current Motor Meter on Alternating current circuit 26th Aug. 92.

The test and curve obtained with this motor #2 are shown on p. 105 with continuous current.

No. of Obs.	No. of Comp.	Length of Magnet	Dynamo Deflection	S	Amps	Rpm.	Rpm/amp	
1	4				1.80	12.5		
2	5				1.86	13.0		
3	6	#2 0.2325	70°	8.367	1.945	13.5		
4	7		85	9.220	2.144	17		
5	8		100	10.0	2.325	19.		
6	9	#2 0.3744	80	8.944	3.267	28.4		
7	10		91	9.539	3.592	32		
8	12		126	11.225	4.225	39		
9	14		170	13.038	4.908	44		
10	16		217	14.731	5.545	50		
11	16	#1 0.915	38.6	6.213	5.685	53.5		
12	18		45.5	6.745	6.712	58.5		
13	20		57.5	7.583	6.938	66		
14	22		69.5	8.337	7.628	74		
15	25		96	9.798	8.965	87	9.706	
16	29		119	10.909	9.982	96	9.62	
17		#1 0.915	96	9.798	8.965	87°	9.706	Continuous current.
18			123	11.09	10.15	98	9.655	

From the last two observations, it appears that there is no sensible difference between the results with alternating and continuous current.

Comparison of Standard Resistances. 2nd Aug. 92.

Spiral of nickel plated manganin. 0.1Ω Compared with my Standard Legal ohm = 1.00028 Ω @ 16.9°C.

Balance at 100 for 99.5Ω on my standard @ 28.6°C against spiral @ 24°C

Result :- Res. of spiral 0.09732 Ω @ 24°C.

Spiral of nickel plated manganin. 0.1Ω compared with grid in series See p. 101

24°C

Test and readjustment of Edison Meter for Mr Brotherhood's house

The resistance of the strips = 0.00995 Ω @ 23°C.

Resistance of various pencils of graphite

Samples for Silvertate

A.W. Faber #2.	12 Ω
"	17 Ω
HHH, HHH	77 Ω
HH H, HHH	82 Ω

Inductance Measurements Aug. 26th

Meter bridge, calibrated as follows:-

Arms of fine german silver or platinoid wire

∴ 45 cms.	=	10·096 ω	= 2·243 ω per cm.	90 cms + leads	20·466 ω
41 -	=	9·403	= 2·293 ω . .	45 - + -	10·370 ω
86 -	=	19·499	= 2·267 ω . .	4 - + -	·947

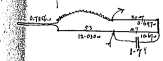
Accepted at 2·27 ω per cm.

Balance wire of manganin.

96·5 cms.	=	2·366 ω	= 0·024482 ω per cm.	100 cm + leads	= 2·502 ω
50 -	=	1·239	= 0·024778 ω "	50 - + -	= 1·268 ω
46·5 -	=	1·127	= 0·024073 ω . .	3·5 - + -	= 0·138 ω

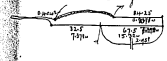
Accepted at 1·02245 ω per cm.

Soft iron wire doubled upon itself in one straight loop.



Res. of loop 0·7956 ω × 1·7 × 10·67 = 14·25 × 10³ cms
Length of wire 197·5 length of loop 98·75
Inductance per cm. of loop 1442·3 approximately
μ of wire 134
Diameter of iron wire 0·080, width of loop about 0·5.

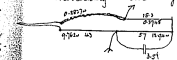
Hard + ready iron wire doubled into a single loop straight.



Res. of loop 0·4042 ω
Inductance 0·4042 × 2·95 × 15·32 = 1·827 × 10⁴ cms.
Length of wire 376 cms. — of loop 188 cms.
Inductance per cm. of loop 97·1
Estimated μ of wire 90.

Diameter of iron wire 0·156 cm. 2·5 cms distance of sides apart.

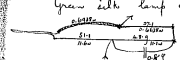
Moderately hard galvanized iron wire, doubled upon itself into a single loop.



Res. of loop 0·2227 ω.
Inductance 0·2227 × 3·5 × 12·94 = 1·281 × 10⁴ cms.
Length of wire 378 cms. of loop 189 cms.
Inductance per cm. of loop 67·74
Estimated μ of wire 60

Diameter of iron wire 0·156 cm 2·5 cms distance apart.

Green silk lamp cord. 713 cms long, wire connected at end.



Res. of loop 0·6938 ω
Inductance 0·6938 × 18·1 × 0·8 = 6·161 × 10³ cms
Inductance per cm. of loop = 8·642.

No appreciable change was discovered in the inductance of this cord, when instead of being left straight, it was coiled up on a wooden reel in 3½ layers.

The inductance balance in this last test was perfect. With all three iron wire loops, it was very imperfect, a mean guess could only be obtained.

The principal sizes of conductor used in American telegraphy are in iron # 6 B+S and #8 B+S.
in copper # 9 - - # 10 -

log) 1618 = 2.089775
0.01113
2.074662 — 116.4.2

23.3
0.7 × 16.14 = 11.3
11

No. of Obs.	Time	Current by Ammeter	Res. of Grid	P.D. on grid	Current by Potentio	Res. of Galvo coils	Res. added to wires	Ratio	Res. of wire
1	14.00	80	0.0016183 = L	1		2730 ω	3810	2.396	3.093 × 10⁻⁴
2	.25	80	@ 0°C.	0.88			4110	2.505	4.471
3	.37	160	0.0016183 =	0.282	173.5		4.210	2.542	
4	.45	"	@ 0°C.	0.279	171.7		4260	2.560	
5	.47	"	0.001625 =	0.278	171.1		4300	2.575	4.184
6	.50	190	@ 23.3°C.	0.326	200.6		4410		
7	.55	190		0.323	198.8		4460		
8	15.0	188		0.323	198.8		4500		
9	.05	185		0.323	198.8		4530		
10	.10	186		0.320	196.9		4560		
11	.12	184.5		0.318	195.7		4560	2.670	4.339
12	.15	231		0.391	240.6		4660		
13	.20	231		0.390	240.0		4780		
14	.25	233		0.395	243.1		4870		
15	.27	230		0.386	237.5		4920		
16	.30	230		0.386	237.5		4900		
17	.35	230		0.386	237.5		5060		
18	.40	230		0.386	237.5		5040	2.846	4.625
19	.42	260		0.444	273.2		5190		
20	.48	257		0.436	268.3		5260		
21	.53	261		0.442	272.0		5390		
22	.57	260		0.441	271.4		5420		
23	15.03	260		0.441	271.4		5480		
24	.05	260		0.441	271.4		5490		
25	.07	260		0.439	270.2		5490	3.016	4.893

Carrying Capacity of Simmons Cable cont.

(111)

The next sample tested was a 30' length of 80,000 circ. mil. cable of 12 for 2000 v. The length 909.5 mm. between pressure wires or 920 mm. between conductor extremities. The conductor is composed of seven wires stranded, each 0.276 in diam. (0.1087") = #12 B.W.G., 11,851 c. mile = 83.167 in all. Area 0.0598258 in² The maximum strand diameter = 0.828 mm. Tot. 0.46776 The insulation consists of two coats of jute laid on in opposite directions and saturated in special compound. (T.C.?)

The diameter over the two coats = 1.374 (0.546, 0.273, 0.109)
" " lead sheath = 1.693 Thickness of sheath = 0.15

" wires of the 30' = 12.02 kgms = 26.5 lbs. = 0.8833 lbs per ft = 1307 gms per m.
" " per mile = 4667 lbs. per kilometre 1307 kgms.

This length was stretched along the floor and connected in series with the large grid. Current was supplied from a continuous current transformer in the dynamo room, derivated from 500 volts. The current through the circuit under 3.15 volts pressure was 70 amp. representing 0.0445 ω res. which includes the transformer armature and connections.

Res. per cm	Resistivity @ 0°C.	R/r	Elevation Temp. of wire °C.	Temp. of air °C.	C²	Watts per linear cm.	Therms per linear cm.	Watts per sq. cm. lead	Temp. air
3.093 × 10⁻⁴									
4.280 × 10⁻⁴	17.92 @ 23.3°	1.093	23.3	–	1600				23.5°C.
4.476	16.40 @ 0°C.	1.143	35.2	11.9	4400	28.614 × 10⁻²			
	0.972 cond.								
4.600		1.175	42.8	19.5	29,275	1.347 × 10⁻¹			
4.770		1.218	52.7	29.4	39,204	1.870 × 10⁻¹			
5.085		1.298	71.0	47.7	56,406	2.868 × 10⁻¹			
5.380		1.374	88.5	65.2	73,441	3.951 × 10⁻¹			

The low conductivity of this conductor (0.972) is perhaps attributable to its stranded form.

80,000 c.mile in hours

Ref. No.	Time	Res. of 1 c.mile	Res. when 80,000 c.miles	Ratio	Res. of 1 c.mile at 0°C	Res. of Cable	Res. per c.m.	Resistivity	R/r	Temp. of wire	Elevation of temp.	Amount Current	Pd.
							3·888 ohms						
1	15·38	2733·5	3914·0	2·4441	0·016252	0·003960	4·30240	1825·0 30°	1·121	30°C.	-	30	0·48
					0·25 ohm								
2	·41							1629·0 0°C					
								0·37 ohm					
3	·45		3990	2·4595								90	0·1[illegible]
4	·48		4010	2·4667								90	0·1[illegible]
5	·51		4010	2·4667		0·004009	4·405		1·133	32·9	2·9°	90	0·1[illegible]
6	16·18		4090	2·4916		0·004050	4·456		1·1146	35·9	5·9°	95	0·1[illegible]
7	·23		4160	2·5122								115	0·22
8	·33		4190	2·5333								200	0·33
9	·35		4190	2·5333		0·004115	4·521		1·163	40°	10°	200	0·33
10	·38		4240	2·5569								200	0·22
11	·40		4320	2·5580								250	0·41
12	·43		4320	2·5580		0·004192	4·607		1·185	45°	15°	250	0·41
13	·55		4440	2·6244								250	0·40
14	·58		4500	2·6646								305	0·51
15	17·01		4520	2·6753								305	0·501
16	·02		4530	2·6757		0·004317	4·7446		1·221	53·5	23·5°	305	0·501
17	·06		4600	2·6933								302	0·500
18	·08		4665	2·7086								332	0·570
19	·10		4670	2·7108								336	0·576
20	·15		4690	2·7215								335	0·567
21	·20		4680	2·7212		0·004407	4·8463		1·246	59·2	29·7°	335	0·565
22	·23		4780	2·7768								335	0·560
23	·27		4860	2·7778								370	0·620
24	·30		4880	2·7785								375	0·628
25	·32		4890	2·7789		0·004532	4·980		1·281	67·2	36·4	375	0·628
26	·35		4940	2·8071								385	0·652
27	·38		4960	2·8114								385	0·652
28	·43	2748	4960	2·8114		0·004572	5·024		1·293	70·0°	38·8°	385	0·644

To find the mean radius of a Twine chord for insertion in the argument $\log_{3e}\frac{R}{r}$

The area of the triangle ABC = $r^2\sqrt{3}$

∴ ∴ quadrant ΔDEF, $r^2(\sqrt{3} - \pi/4)$

$= 0.6135\, r^2$

Let $\pi R^2 = \sqrt{\pi r^2 + 0.6135\, r^2}$

$R = r\sqrt{7 + 0.2133}$ $\qquad R = r\sqrt{7 + \frac{0.6135}{\pi}}$

$= 2.7417\, r$ $\qquad \approx 1.7026$

This value of R makes the area PAR = area RST

$r = 0.139$ ∴ $2.7417\, r = 0.3792$

$R = 0.6870$

$\log_{3e}\frac{R}{r} = \log_{3e}\frac{0.687}{0.3792} = \frac{\bar{1}.83646}{\bar{1}.57922}$

$\frac{0.687}{0.3792} = 1.811$

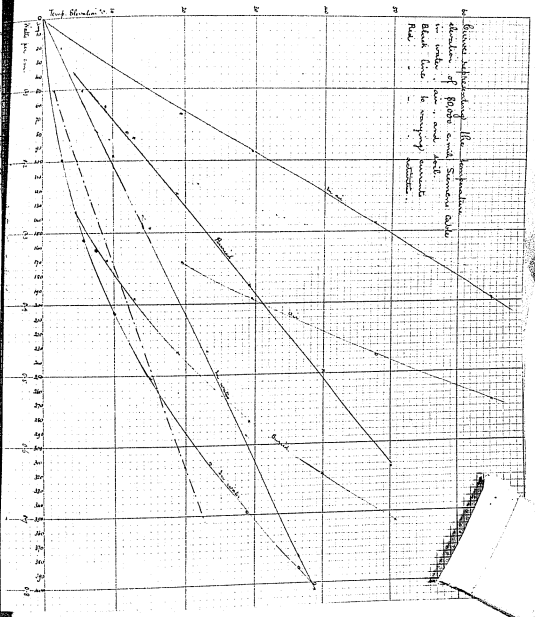
0.59692

10.026

$\log_{10}$

$\frac{2.3}{\log_{3e}\frac{R}{r}} = \frac{2.3}{0.59692} = 3.856$

4137020
3641157
495863
396690
0.0236228



Curves showing the Resistance, Temp. Elevation, Current & Pd. for a 80,000 c.mile Submarine Cable in water.

Black line : Resistance
Red line : Temp. Elevation
Blue line : Current
Pink line : Pd.

Carrying Capacity of Siemens cable contd.

The length tested in air on the preceding pages were placed in the iron pipe, see p. 106, and the test repeated with water flowing along beside surface, in the pipe.

Date	Potto current	C^2	Watts per lineal cm^{-3}	Therms per lineal cm	Temp. of water	Means	Temp. of air	$\frac{\text{Volts}}{\text{Ohms}}$	ρ	K	Feed water c.c. of H_2O per sec.	Therms observed
11	38·77	1503.	6.55×10^{-3}	1.56×10^{-3}	out / out 32 / 29·8	30°	23·2°	6.726×10^{4}			146·7	
	79·98											
	95·36											
	96·60											
4·5	103·40	9692·4	4.270×10^{-2}	1.017×10^{-2}				1.035×10^{3}	30002	0·000 3331	"	
5·4	155·1	24056	1.072×10^{-1}	2.552×10^{-2}				1.125×10^{3}	24034	0·000 4108	"	
	206·1				29·5 30·0	29·9°						0·6×147
	206·1											= 2803
6·1	206·1	42477	1.920×10^{-1}	4.571×10^{-2}				2.303×10	2303	1·000 4342	"	3.15×10^{-2} per cm
	252·9											
	282·9											
7·9	284·8	63450	2.923×10^{-1}	6.958×10^{-2}				1.513×10^{3}	2270	1·000 4405	"	
	316·8				29·6 30·5	30·2°						66×147
	312·6											= 7207
	313·2											
3·4	310·8	92220	4.660×10^{-1}	1.109×10^{-1}				9.487×10	2230	0·000 4254	"	0.94×10^{-2} per cm
	353·2											2·2×147
	350·7											324
	348·8											1027
	347·6											
7·9	344·5	121034	5.862×10^{-1}	1.396×10^{-1}	29·6 29·6	30·0°		7.214×10	21624	1·000 4621	"	1.67×10^{-2} per cm
	398·0				29·8 31·6	30·6°					73·3	2·0×73·3
	390·7											146·6
	390·7											
0·7	388·9	152646	7.602×10^{-1}	1.810×10^{-1}				5.815×10	2117	0·000 4724	"	1.666×10^{-2} per cm
	401·8				30·4 31·4	31·2°	25·0°					2·0×73·3
	401·8											146·6
0·7	399·7	160560	8.066×10^{-1}	1.921×10^{-1}				5.479×10	2126.	0·000 4704	"	1.666×10^{-2} per cm

Reading No.	Time	Current by Ammeter #1 (Range 0-100)	Current by Ammeter #2 (Range 0-200)	Current by Ammeter #3 (Range 0-300)	Res. of yard	PD across yard	Current by Potentio.	Res. of Galvo circ.	Res. added to yard & cable	Ratio
1	15.48	20	-	-	0.001625Ω @ 23°C.			2734.5Ω	130	0.9546
2	.52	60							120	
3	.54	65				0.115	70.8		120	
4	.55	120	75	150		0.202	124.3		120	0.9580
5	.58	120				0.205	126.2		120	
6	16.02					0.205	126.2		115	0.9596
7	.07	150	160	220		0.305	187.7		95	
8	.12	180				0.305	187.7		85	
9	.18	180				0.305	187.7		75	
10	.22	177				0.304	187.1		65	
11	.24					0.303	186.5		60	0.9787
12	.28	240	215	270		0.391	240.6		40	
13	.33	239				0.389	239.4		30	
14	.36	239	220			0.390	240.0		17	
15	.38	240				0.394	242.5		15	
16	.40					0.393	241.9		2	
17	.48					0.393	241.9		7	1.00256
18	.50	302	285	320		0.510	313.9		22	
19	.58	302				0.497	305.9		60	
20	17.03	300				0.498	306.5		75	
21	.08	300				0.498	306.5		81	
22	.09	300				0.498	306.5		90	
23	.10	300				0.497	305.9		95	
24	.14					0.495	304.7		105	
25	.16					0.505	310.8		110	
26	.18					0.500	307.8		115	
27	.20					0.498	306.5		117	1.0428
28	.22	350	350	410		0.586	360.6		145	
29	.26	347	345	410		0.582	358.2		155	
30	.34	345	342			0.580	357.0		185	
31	.41	-				0.582	358.2		210	1.0768
32	.42	420	430	460		0.719	442.5			
33	.47	420	420			0.716	440.7		285	
34	.51	420				0.712	438.2		345	
35	.56	420	430	455		0.715	440.1		380	
36	.57					-		2734.5	385	1.1408

The next sample of cable was a 30' length of 208,000 c.m.(C.C.) 2000 v. #36.
The length between conductor extremities was 920.7
" weight of this length 18.6 Kilos = 41 lbs.
" " = 20.2 gms per cm. = 2.1357 lbs per ft.
" " = 2020 kilos per kilometre = 7165 lbs per mile
" length between pressure wires = 906.2 cms. between ends of lead shielding 903.2
" " left bright pressure wires for mains connection = 7 and 7.5 cms (estimated)
" strand consists of 19 wires each #10 B.&S. 12 outside over 7 inside in opp. directions
" Diameter of each wire = 0.2588 cm. = 0.1016" #10 B.&S.
" Cross sectional area - - = 0.05228 cm² 10,323 cir. mils.
" Total - - - of strand = 0.99334 cm² 196,150 cir. mils.
" Maximum diameter of strand = 1.361 0.536"
" Diameter over two coatings of jute soaked in compound 1.715 - 0.675"
" Thickness of insulator = 0.177 = 0.070"
" Diameter over lead sheath = 2.201 = 0.8665". Thickness of sheath = 0.243 = 0.096"
The cable was laid in a nearly straight line along the floor in [illegible] heat

Reading	Res. of cable	Res. of cable from	Resistivity @ 0°C.	R/r	Temp. of cable	Elevation of temp. of conductor	C²	Watts per linear cm.	Watts per sq. cm. of sheath	Temps.
	0.0001551 @ 23.0°C.	1.587×10⁻⁴ / 1.711×10⁻⁴	1.587×10⁻⁶ / 102.4%	1.0 / 1.0792	23°C	0°				
	r									
	0									
	0.0015872	1.7205×10⁻⁴		1.0948	24.5°C	1.5°	15.7715	2.714×10⁻²	0.003925	
	0.0015902	1.755×10⁻⁴		1.120	29.7°	6.7°	35.081	6.157×10⁻²	0.008906	
	0.001629	1.797×10⁻⁴		1.147	36.2°	13.2°	58.322	1.018×10⁻¹	0.07516	
	0.0016945	1.870×10⁻⁴		1.1932	47.0°	24.0°	94.586	1.768×10⁻¹	0.02557	
	0.0017150	1.931×10⁻⁴		1.232	56.0°	33°	128.522	2.481×10⁻¹	0.03588	
										37° sheath
	0.0018524	2.046×10⁻⁴		1.306	72.8°	50°	193.952	3.967×10⁻¹	0.05737	44.0° sheath

200 000 emit. in water

Read Obs.	Time	Rise of G	Rise added for balance	Ratio	Rise of grid & bar	Rise of cable	Rise for 1 cm of cable	Resistivity @ 0°C	R/r	Temp. of water	Elevation of temp.	Accumulator current	R/r
1	14.26	27.70	76 b.p.		0.0016250		1.5746×10^{-4}			26.5°C.		110	0.6
2	.29		76 "		@ 24°C								
3	.33		81 "									110	
4	.35		86 "					Cond. 1.021				125	0.4
5	.47		86 "	0.96993		0.001576	1.7317×10^{-4}	1.561×10^{-4} 1.797 0.28	1.1065	26.5°C.	0	155	0.4
6	.53		81 "										0.4
7	.57		79 "									210	0.3
8	15.03		74 "									205	0.3
9	.06		74 "	0.9740		0.001523	1.746×10^{-4} "		1.1111	27.7°C.	1.2°	205	0.3
10	.10		71 "									205	0.3
11	.17		65 "									260	0.31
12	.21		65 "	0.9793		0.001513	1.756 "		1.1171	29.05	1.45°	255	0.31
13	.23		51 "										0.31
14	.30		41 "									320	0.39
15	.33		39 "									320	0.39
16	.37		39 "	0.9861		0.001505	1.768 "		1.1204	30.85	5.60°	320	0.39
17	.39		21 "									385	0.47
18	.46		11 "									380	0.51
19	.49		6 "									380	0.51
20	.52		6 "	0.99785		0.001629	1.7897 "		1.1384	34.1	8.8°	380	0.52
21	.55		16 b.p.									452	0.705
22	16.00		24 "									450	0.697
23	.02		29 "									450	0.703
24	.05		31 "									450	
25	.09		34 "	1.01227		0.001625	1.8152 "		1.1549	38.0	12.9°	450	0.706
26	.11		54 "									520	0.837
27	.16		76 "									520	0
28	.27		84 "									525	0.837
29	.28		89 "										0.832
30	.30		94 "									525	0.832
31	.32	27.76	94 "	1.03293		0.001680	1.8241 "		1.1745	43.75	18.40°	525	
32													

Taking d as 1.35

D = 1.715

$\log D = 0.2342261$

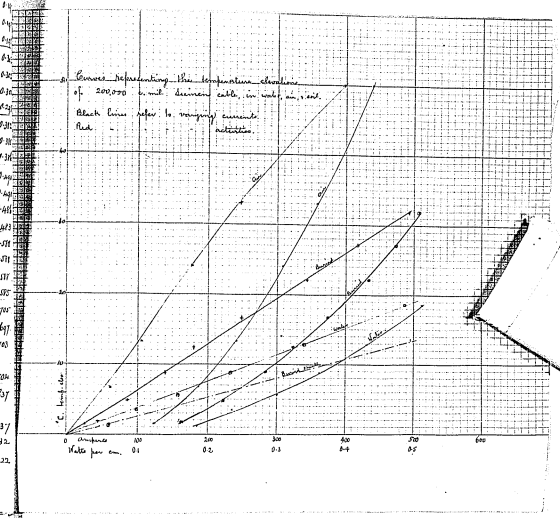
$\log d = 0.1303338$

0.1039303

$\frac{D}{d} = 1.2705$ $\log_e 1.2705 = 0.239$

7.0167409
0.3622157
1.3769566
0.7981809
1.4202243
23

26316



Carrying Capacity of Simons Cable Sept. 2nd

The length last tested was inserted in the same iron pipe as hitherto used, and the following measurements made with Water flowing through the pipe.

Potential length C	Corrected Potential Current	C.A.	Volts per Ohm in Cm.	Therm per Ohm in Cm.	Temp of water °C	Mean	Temp of Air	Sp. Ht of Water at 11.6 lbs.	ρ	K	Feed water	Therm observed	
					out / out								
116·3	1"				26·2 / 26·1		20·8°C	1.277×10^{3}					
					26·5 / 26·6								
121·3													
121·9					26·6 / 26·5								
121·9	121·9	14,860	2.584×10^{-3}	6.133×10^{-3}									
186·5					26·2 / 26·0	26·1							
185·9													
181·6													
193·4	185·1	34,242	5.981×10^{-3}	1.426×10^{-3}				1.848×10^{3}	2.220	0.000[illegible]			
235·1													
236·9					25·6 / 25·4	25·6							
237·5	236·5	55,932	9.826×10^{-3}	2.338×10^{-3}				1.126×10^{3}	3.885	0.000237[illegible]			
301·5													
301·5					25·0 / 25·5	25·3	22·0						
299·1													
297·3	299·9	69,900	1.590×10^{-3}	3.785×10^{-3}				6.952×10^{3}	3.893	0.000256[illegible]			
361·8					25·0 / 25·6		21·0						
361·8													
361·8					25·5	25·3							
360·9	361·3	130,538	2.337×10^{-3}	5.564×10^{-3}				4.730×10^{3}	4.162	0.000240[illegible]			
433·9					24·8 / 25·6		22·5						
429·0													
432·6					25·0	25·1							
433·3	432·2	186,850	3.341×10^{-3}	8.074×10^{-3}				3.257×10^{3}	4.201	0.000237[illegible]			
515·2					24·6 / 25·7	25·2							
515·2													
512·1													
505·9	512·1	262,246	4.569×10^{-3}	1.158×10^{-3}	24·9 / 25·0		20·5	2.273×10^{3}	4.193	0.000[illegible]	70 c.c. per min.	0.8875 therms per Ohm in Cm.	
1600													

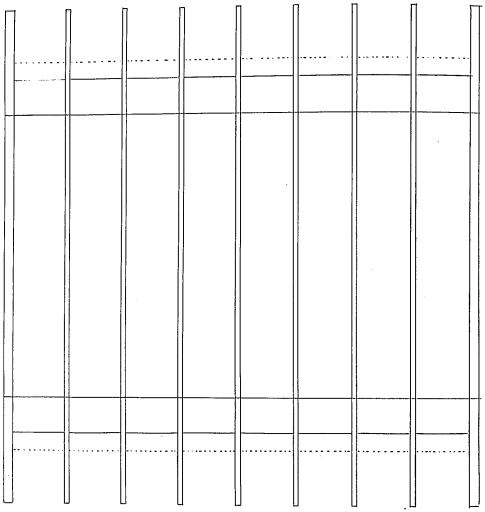
Test of the #12 B.S. cable on the floor of heating room.

Test No.	Time	Rise of Gj. cable	Rise water for balance	Ratio	Rise of gas at temp	Rise of wire	Rise of wire per cm. $\frac{4 \cdot 9 \times 10^{-4}}{8 \cdot 366 \times 10^{-3}}$	Resistivity @ 0°C	$\frac{R}{r}$	Temp. of wire	Elevation of temp of wire	Commutator current temp	PD on gas
1	9.26	2735	14.1 gal	0.9949		0.04932	0.04905	162.1 S.C.M. 19.3 J.C.M.	1.092	23°C	-	13	
2	.44		15.1 min	1.0066								15	0.920
3	.47		41.	1.01499								18	0.937
4	.52		53.	1.01938								18	0.939
5	.54		54.	1.01974								18	0.939
6	10.03		59.	1.02157								18	0.936
7	.12		63.	1.02304		0.05043	5.517		1.123	30.5	7.5°	18	0.933
8	.14		93.	1.0324								24	1.255
9	.20		103.	1.03766								24	1.238
10	.25		121.	1.04424								24	1.237
11	.32		125.	1.04577								24	1.255
12	.36		125.	1.04577		0.05153	5.640		1.1248	36.3	13.3°	24	1.231
13	.39		173.									32	1.650
14	.46		209.									32	1.645
15	.50		215.									32	1.655
16	.52		221.									32	1.665
17	.58		225.	1.08228		0.05336	5.837		1.188	45.75	22.58	31	1.666
18	11.00		273.									37	1.932
19	.03		285.									37	1.930
20	.05		305.									37	
21	.10		320.									37	1.918
22	.13		325.	1.1188		0.05545	6.0344		1.230	55.5	32.°	37	1.916
23	.20		398.									43	2.222
24	.25		423.									43	2.216
25	.27		433.									43	2.206
26	.33		448.	1.1638		0.05737	6.277		1.278	66.5	43°	43	2.210
27	.40		550.										2.472
28	.45		555.										2.472
29	.46		568.										2.452
30	.48		578.										2.450
31	.51	2744	579.	1.2117		0.05973	6.534		1.330	75.5	55°.		2.466

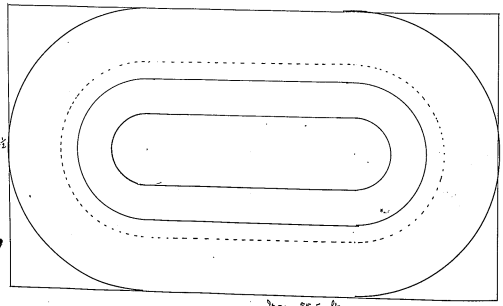
Carrying Capacity of Siemens Cables contd. Sept. 6th

(115)

Temp. Gas	Potential C.	Mean C	C^2	Watts per linear cm.	Thickness per linear cm.	Calculated temp. of sheath	Temp. elevation of sheath	Convection per sq. cm. watts	Total convection per linear cm.	Radiation per linear cm.	Radiation per sq. cm.	A_g	m.
23°.													
	18.66												
	19.00												
	19.05												
23.2°	19.05	18.94	358.72	1.979×10^{-2}	4.712×10^{-2}	64	26.1°	2.9°	0.00507	0.01472	0.01730	0.00918	0.00155
	18.98			0.01979 0.00523 0.01472									
	18.92												
	24.24												
	25.11												
	25.09	24.73	611.57	3.45×10^{-2}	8.214×10^{-2}	60	30.3	7.7°	0.02260	0.0219	0.0219	0.00885	0.0089
	24.24								6				
	24.97			0.03345 0.0154 0.0229									
	33.47												
	33.37												
	33.57	33.596	1128.9	6.589×10^{-2}	1.569×10^{-2}	91	36.6	18.5	0.02362	0.04237	0.04237	0.0708	0.07844	2.3
	33.77			0.06639 0.02154 0.04237									
	33.80												
	39.19												
	39.18												
		39.03	1523.3	9.392×10^{-2}	2.212×10^{-2}	12	43.5	20°	0.0350	0.05792	0.05792	0.02311	0.0113	2.072
	38.91			0.09392 0.05350 0.05792									
43.5°	38.86												
	45.07												
	44.95												
	44.75	44.90	2016.0	1.265×10^{-1}	3.013×10^{-2}	154	51.1	27.6°	0.0483	0.07225	0.07225	0.0362	0.0169	1.975
	44.83			0.1265 0.0483 0.07225									
	50.13												
	50.13												
53.6°	49.73	49.94	2494.0	1.652×10^{-1}	3.886×10^{-2}	192	59.3	35.8°	0.08264	0.10058	0.10056	0.04664	0.0216	1.98
	49.69			0.1652 0.08264 0.10056									
	50.02												
	49.70												



Plan ½



Cross section ½

Total weight when constructed 154.5 lbs.
" resistance " " 7.954 ω @ 24.6°C.
" number of turns " " 2048

Iron 99.5 lbs.
Fiber 1.34 "
Paper 30.5 "
Wire 24.16
154.50

Design for a powerful Flat Magnet. 8th Sept.

The winding space for this magnet is represented on the opposite page. With the partitions of copper ⅛" thick to increase the convective surface, the carrying capacity of the winding should be considerably augmented.

With #15 B.&S. copper wire s.c.c. from 0.072" to 0.097", there will be 16 turns per layer and 11 layers in each partition or 176 turns. The length of the mean turn will be 22" or 1.83' so that the wire in each block = 322.6' = 0.8274 ω @ 100°C. or 0.6422 ω @ 20°C. = 5.065 lbs.

On slab = 2580.8' = 6.6192 ω " " 5.136 " " = 40.520 "

The number of turns on the slab = 1408.

Filling up to the dotted lines with the same wire, 1⅛" × ½". There will be 16 layers of 16 turns = 256 turns per block, and the length of the mean turn = 23" = 1.918' so that

per block = 491' = 1.259 ω @ 100°C = 0.9776 ω @ 20°C = 7.71 lbs. = 256 turns.
on slab = 3928 = 10.08 ω " " = 7.8208 ω " = 61.68 " = 2048 "

Test of a Thermo-electric cell 9th Sept. 92

A dish of copper about 12.5 cms. in diam. and 7 cms. deep, riveted to a handle, was placed on a furnace. In the dish was placed a piece of copper oxide, and on this powdered caustic soda. The ~~whole~~ ~~was~~ dish was then heated to a dull red heat, the soda melting. A lump of coke, exposing some 30 sq. cms. of surface to the liquid, was plunged in the melted caustic soda, and supported in the dish but not touching the true. Wires were taken from the dish and from the carbon plate, to a Weston ammeter and extra res: with leads of which the following measurements were taken.

Leads 0.065 ω
Ammeter 0.007 ω
Extra res: 2.348 ω

Simpson ammeter
Total without extra res 0.072 ω, with 2.42 ω

This was observed for emf and int. res: reading.
On first dipping in the coke, a current of 0.5 amp. was observed. This diminished and reversed. After reversal the current increased up to 1.5 amperes, without extra res and 0.75 amp. with, making the EMF 0.32 volt, and the int. res: of the dish cell, 0.14 ω. This current was steady, at any one moment, but would vary with a change in the position of the coke plate. When the cell became red hot bubbling took place in the liquid, and the liberated gas finally ignited. It was probably CO. The EMF still continued under those conditions, but slightly diminished. It reached a maximum when the ebullition ceased.

On the following day tried a cell made up in the same dish and under the same conditions except that caustic potash was used in place of caustic soda. The potash melted much less readily. The best results gave 0.16 volt and 0.13 ohm. int. res. The caustic soda cell was decidedly preferable.

$\frac{100}{0.0793} = 1007$ $\quad \frac{1.228}{1.007}$ ampere = 1 ampere = 1.220

Tests of Storage Cells – Ernest – continued from page 93.

No. of Test	Date	Charging current	Charge	Discha current	Discharge	C	Charge Transfer	Charge Mean	Discharge Transfer Ranges	Discharge Transfer Smalls	Discharge Cell 8 amphours Ranges	Discharge Cell 8 amphours Smalls
1	12th Aug.	5 amp.	100.5		51.7		0.0845 0.0845	0.0845	0.0[illegible]	0.0675	48.3	55
2	15th		157.2		83.2		0.161 0.159	0.1110	0.070	0.107	78.6	87.7
3	18th		124.1		81.5		0.110 0.111	0.1105	0.072	0.108	80.9	82.0
4	20th		114.3		84.2		0.134 0.132	0.133	0.074	0.1014	83.1	85.3

Tests of a model Edison motor for Battery.

Resistance coil of field 0.085 ω
" " " armature 0.23
" " " motor 0.315 ω

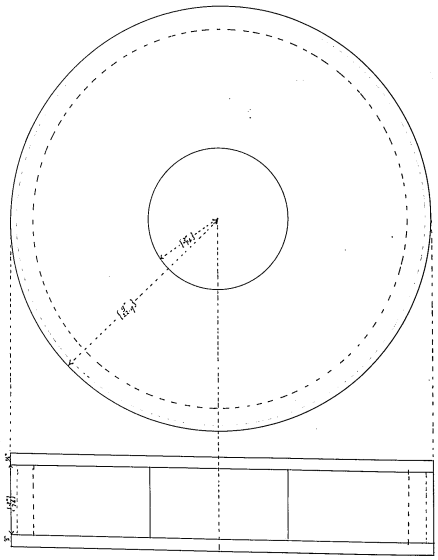
Clearance armt. entrefer, as constructed 0.015".
Speed running light, on one storage cell 900 rpm current 1.75 J.
" with fan on 4 Lalande cells 1.4 volts at terms. 460 rpm 2.32 J.

Porter motor.
Res. of field 0.34 ω
" " armature 0.30 ω.
" " motor 0.64 ω.

Speed, running with one fan, on 4 Lalande cells. 1.99 volts at terms 470 rpm. 1.70 J.

After grinding down the armature surface of the Edison model 0.010" until the entrefer was 0.025", the speed increased to about 1100 rpm. and the current to about 2.0 amp.

Test of a model of the second 100 built by the Phonograph Works.
With new fan whose blades are bent across over a drum 18" in diam.
The line AB is a generating line of the cylinder on which the blade is bent.
The speed was 1220 rpm with one of these taken at random on 4 cells freshly set up, taking 3.4 amp.
The speed was 1360 rpm. with the same fan on a motor whose entrefer had been increased (A above) from 0.015" to 0.025". current 3.5 amp.



Area of one side of cylinder	1411.9 sq. cm.
Circumference of cylinder	71.94 cm.
Area of cylinder face	730.8
Both sides	923.8
Total surface	1554.6
Energy per sq. cm.	10 watts
Energy permissible	155.5 w.

On the winding for a large drum magnet.

The core will be of wrought iron, and the flanges of cast iron.
The winding will occupy the roller up to within one inch of the rim.
The contents of the space = 519 cub. in. = 100 lbs. of wire roughly. allowing 150 watts at 1·25 amp. = 1·2 w or 0·012 ω @ 60°C = # 10 B.W.G.

The weight of the iron spool with axle and dog is 104 lbs.
The wire adopted = # 11 B.W.G. d. 12" d.c.c. 0.136".
The body insulation is 0.020" fibre all round.
There should be 21 turns per layer and 36 layers.
The mean diam = 11". Thence inc. 34.56" = 2.88' Mean diam' 11.75" Mean circ. 3.076'
Total estimated turns = 756
Total estimated length = 2177' 2322
- - weight = 98 lbs. 101.5
- - resistance = 1·56 ω cold @ 20°C 1·785 ω warm @ 60°C. 1·847 @ 20°C 1·907 @ 0°C
Actual winding 756 turns in 37 layers averaging 20.5 turns per layer
Resistance 1·857 Ω @ 19.4°C.

Analysis of a Weston ammeter 15th Sept. 1892.

This is a 5 ampere meter marked No. 251.
The moment of the springs at half load = 3.5 amp. = 0·361 cm. gms. by 1st trial.
0·343 - - 2nd trial.
Mean 0·352 - -
ditto at 5·0 amp = 0·704 - . (full load) 90°

This represents 2·816 cm. gms or 2762 dyne-cms. for one revolution or 2π.
The radius of the pointer extremity is 8·9 cms (3.5")
- mean radius of the coil is 1·3 Mean length of one side 3·3.
The coil has 25 turns of wire, making 50 full passages, and has a resistance of 0·56 ω @ 22°C, in circuit with a resistance of 0·130 ω.
The total resistance of the shunt path containing the coil is 0·690 ω
- resistance of the main shunt is 0·0070 ω so that the saturating current in the coil is 1/99th of the main current, or 5/112 - 20 mm at full load.

The total length of wire in the field is 25 × 2 × 3·3 = 165 cms.

$$H \times 5.0 \times 10^{-3} \times 1.65 \times 10^{4} \times 1.35 = 690$$
$$11.14 \times 10^{-3} H = 690$$
$$H = 6083 \text{ say } 600.$$

The polar surface is about 10 sq. cms and the cross section of the magnet about 3 sq. cms. The armature about 0.22. The reluctance of each gap is about 0.022 making 0.044 in all. While 6000 lines are accounted for in the gap, the intensity in the magnet for this flux would be only 2000. The F.D. across each air gap would be 13.2 or 26.4 between magnet poles.

The resistance of the ammeter whose full load is 0·25 ampere is 0·0352 and it would seem from these two instruments that Weston's shunt or main shunt resistance are $\frac{0.035}{c}$ Ω where c = ampere at full load.

The resistance of a 150 volt voltmeter is 16,000 ω, so that its full load current is 9.4 milliamperes. The instrument began to be affected by the stray field from the #20 dynamo at some 8 feet distance.

Carrying Capacity of Siemens Cable. Sept. 9th

All four samples previously tested in air and water, were buried in the ground by the Galvanometer room wall, some 90 cms away. The depth was 76 cms. The smallest wire is parallel to and distant from the wall. The others are 16 cms further off in order of size. The outside to outside horizontal distance of the first and last being 50 cms. The cables were bared, and wires soldered on 720 cms from each other. 360 cms each from the center). In the largest size the distance was 720.5. This leaves 90 cms approx. of cable rising vertically to the surface at each end and also a pressure wire beside it. The trench was filled in with the red soil, but no large stones. There was no pavement placed above.

Not Bare, buried at 87 diameter

No of Obs	Time	Resc. of 4 coils	Resc. added for balance	Ratio	Resc. of grid at temp.	Resc. of wire	Resc. of wire per cm. +.038 at 0°	Resistance @ 0°C.	R/r	Temp. of wire	Elevation of temp. of wire above room	Ammeter Current	P.D.
										24.			
1	8.47	2705	792 bad	0.7735	0.0493	0.03813	5.298×10^{-4}	1597 (see bad for p. 107)	1.0495	23.75	-	16.5	0.87
2	.53		782										
3	9.05		780									15.8	0.82
4	.17		780	0.7764		0.03927	5.315		1.0485	24.5	0.75°		0.78
5	.30		750									24	1.24
6	.30		742									25	1.29
7	.55		757	0.7815		0.03853	5.351		1.106	26.23	2.5°	22	1.11
8	.05	2710	730									28	1.47
9	.22		720									27.5	1.45
10	.28		720	0.7[illegible]		0.03846	5.411		1.1183	29.3	5.65°	27.	1.44
11	.31		685									33.5	1.76
12	.36		680									33.5	1.78
13	.42		677									33.0	1.78
14	.50	2710	676	0.8006		0.03947	5.482		1.1330	32.8	9.05°	33.0	1.78
15	.58		620									40.	2.09
16	11.03		616									40	2.09
17	.08		613									40	2.09
18	.14		613	0.8165		0.04021	5.584		1.154	37.8	14.05°	40.	2.09
19	.17		540									45.	2.51
20	.22		532										2.81
21	.27		532	0.8366		0.04124	5.727		1.184	44.8	21.05°		2.81
22	.30	2720	440										3.97
23	.40		412										2.97
24	.45		402										2.97
25	.50		397										2.97
26	.55		392										2.97
27	.57		388										2.97
28	12.00		387	0.8753		0.04315	5.993		1.2388	57.5°	33.75°		2.97

No of Obs	Potential C.	Mean C.	C^2	Watts per 1 mm cm.	Thermal per 1 mm cm.	Color temp. of sheath	Temp. elevation of sheath	Watts per sq. cm. of sheath	Thermal per sq. cm. of sheath			Inverse Ratio of flow	Temp. surface cable
1	17.69											1.2923	
2													
3	16.80	16.77	281.23	1.445×10^{-2}	3.56×10^{-1}			6.041×10^{-3}	1.438×10^{-2}				
4	15.82											1.2878	
5	25.19												
6	26.24	24.66	608.12	3.254×10^{-2}	7.746			1.315×10^{-2}	3.131×10^{-2}				
7	22.55											1.2794	
8	29.81												
9	29.81	29.48	869.07	4.703×10^{-2}	1.12×10^{-1}		1	1.900×10^{-2}	4.524×10^{-2}				
10	29.11											1.2657	
11	35.82												
12	35.61												
13	35.61	35.62	1268.75	6.455×10^{-2}	1.656×10^{-1}			2.811×10^{-2}	6.692×10^{-2}				
14	35.45											1.2490	
15	42.51												
16	42.55												
17	42.51	42.50	1806.25	1.009×10^{-1}	2.402×10^{-1}			4.078×10^{-2}	9.710×10^{-2}				
18	42.43					22.75	1°					1.2262	
19	51.31												
20	50.83												
21	50.27	50.80	2580.64	1.478×10^{-1}	3.519×10^{-1}	3°	25.75	3°	5.973×10^{-2}	1.422×10^{-1}		1.1956	
22													
23													
24													
25													
26													
27													
28	60.24	60.24	3628.36	2.175×10^{-1}	5.179×10^{-1}	5.5	32.25	8.5°	8.788×10^{-2}	2.092×10^{-1}		1.1423	25.4°C.

$$\frac{2719}{10} \quad \frac{2721 + 887}{2721} :: 3.08 : 2721 \cdot$$

log 0.00994 54 = 3.997 9976
1.00233 = 0.001051

3.996 9976 = 0.00994 209

3.08 = 3.5475555
1.5185531

2721 = 3.4347357
2.8818296

0.012073 ∞

No. of Obs.	Time	Res. of G. coils	Res. added for balance	Ratio	Res. of grid at temp.	Res. of wire	Res. of wire from	Resistivity @ 0°C.	R/r	Temp. of wire	Elevation of temp. of wire above normal	Commutator current	P.D. on grid
1	13.35	2673	1025	0.7227	0.11073	0.0057725	1.128	1600 × 10⁻⁶ / 719 × 10⁻⁶	1.074	18.6°C		60	0.784
2	.38		1000				1.112					-	0.800
3	.52		970									-	0.808
4	14.20	2680	965	0.7352		0.008876	1.233		1.093	23.25°	14.65°	-	0.812
5	.22	2680	910									75	0.822
6	.46		895									-	1.047
7	.53	2690	895	0.7583		0.009058	1.258		1.115	28.5	9.9°	-	1.036
8	.55	2690	805									1000	1.146
9	15.00		779									-	1.410
10	.10		760									-	1.410
11	.20		745									-	1.405
12	.50	2700	745	0.7837		0.009462	1.311		1.165	40.4	21.8°	-	1.402
13	.53	2700	670									120	1.679
14	16.02		620									-	1.684
15	.15		615									-	1.680
16	.33	2710	610	0.8163		0.009855	1.369		1.214	51.8	33.2°	-	1.663
17	.35	2710	522									145	1.987
18	.45		457									143	1.975
19	.52		447									142	1.962
20	.58		417									146	2.010
21	17.05		405									-	2.020
22	.14		395									-	2.020
23	.18	2715	395	0.8730		0.01054	1.464		1.299	71.0	52.4°	-	2.020
24	.20	2715	260									170	2.376
25	.29		220									-	2.360
26	.38		195									-	2.330
27	.48		170									-	2.330
28	.55	2717	167	0.9020		0.01137	1.579		1.400	94.8	76.2°C.	-	2.330

Carrying Capacity of Siemens Cable earth

(120)

14th Sept. 92

The sample of #6 B.S. cable buried in the ground was next tested.
The resistance of the grid in multiple 0.01207 ∞ to temp.

156.6 diameter radius

Temp. of Cable	Potentio C.	Mean C.	Cu	Watts per linear cm.	Therm. per linear cm.	Cable temp. of sheath	Temp. elevation of sheath above normal	Watts per sqr. cm. of sheath	Therm per sqr. cm. of sheath				Zero ratio
	65.22												1.3834
	66.12												
	66.54												
	67.11	66.25	4.389	5.412×10^{-7}	1.209×10^{-7}	16.9	10.3°	0.65°	1.208×10^{-3}	2.878×10^{-3}			1.3601
	84.46												
	86.53												
	85.63	85.54	7.317	9.206×10^{-7}	2.192×10^{-7}	75°	21°	2.14°	2.455×10^{-3}	4.892×10^{-3}			1.3327
	117.2												
	116.5												
	116.5												
	116.1												
	115.9	116.4	13.544	1.711×10^{-6}	4.2011×10^{-7}	18.0	22.4	3.8°	3.975×10^{-3}	9.465×10^{-3}			1.2759
	128.8												
	139.2												
	138.8												
	137.4	138.5	19.182	2.626×10^{-6}	6.253×10^{-7}	26.3°	25.5°	5.9°	5.563×10^{-3}	1.346×10^{-2}			1.2251
	164.2												
	163.2												
	162.2												
	166.1												
	167.0												
	167.0												
	167.0	165.3	27.324	4.091×10^{-6}	9.526×10^{-7}	40.0	31°	12.4°	8.920×10^{-3}	2.127×10^{-2}			1.1125
	195.6												
	195.1												
	192.6												
	192.6												
	192.6	193.7	37.520	5.927×10^{-6}	1.411×10^{-6}	59.5°	35°	16.9°	1.323×10^{-2}	3.149×10^{-2}			1.0614

Report of Heat Test on Siemens Cable, Va C Company

— Cable —

Length Feet	Area C.M	Outside Dia	Core Dia	Thickness of Insulation	Thickness of Lead	% Increase	Corresponding to % Rise in Temp
150.	1000000	1.745"	1.575"	.177"	.110	31.8%	15.11%

— Pressure wire —

					Resistance in ohms Cold	Hot	% Increase	Corresponding to % Rise in Temp.
450	6.59	170"	.083"	.053"	1.24	1.56	25.5	122.5

1100 ft. of cable on drum balance in air.
50 ft. " " with 710 load.

Cable showing volts drop in Cable at different periods of Test.

Time	Current Amperes	Volts Readings
10.00	1075.	5.12
10.20	1075.	5.22
10.40	1050.	5.33
11.00	1045.	5.35
11.20	1075.	5.70
11.40	1075.	5.79
12.00	1100.	5.96
12.20	1110	6.25
12.40	1075.	6.11
1.00	1075	6.15
1.20	1075.	6.51
1.40	1075.	6.61
2.00	1075.	6.73

Temp of room at start 21°C
" " " " End 22°C = 72°F
" " out Side of Cable at Start 21°C = 70°F
" " " " " " End 31°C = 87°F

No current through P.W.
Insulation at start 1200 megohms
" " Hot 1 " "

W. S. Clark
J.G.S.

Measurements of Electro-osmose.

15th Sept.

After several preliminary and unsuccessful trials, adopted the following method of measurement.

Two porous cells of the dimensions indicated on the opposite page were connected in series. They were soaked in paraffin wax at their bases and rims, and were filled to a convenient height with $ZnSO_4$ solution in H_2O whose density was 1.054 @ 20°C. When superficially dried they were quickly weighed and replaced in their respective humbles, containing the same solution up to as nearly as possible the interior level. Weighed zinc plates formed the electrodes, one in each humbler and one in each porous cell. A few drops of pure paraffin oil were added to prevent loss by evaporation. The current was from 126 volts through three cells and 3 120 volt lamps in series. After a noted interval of time, the porous cells were removed, their zincs carefully lifted out with as little superfluous liquid as possible, their exterior surfaces gently rubbed dry, and their weights observed. The current was sent through the cells so as to lower the level in one and raise it in the other, so as to obtain a fair mean transfer.

No. of Obs.	Time	Interval	Weight of Zinc Before	Zinc After	Gain	Loss	Mean transfer	Amp-Hrs	Weight of cells Before	After	Gain Loss	Mean Transfer	Transfer per amp-hr
1	started 9.40		76.860	76.580		0.266	0.442		122.900	119.985	-2.915		
			57.030	57.650	0.620			0.320				2.968	11.35 grammes
		2.25 hrs.	68.265	68.648	0.383			0.2614	120.990	124.010	+3.020		
	stopped 11.56		64.640	64.630		0.010	0.1945	0.1627					10.77 c.c.
2	started 13.45		57.680	57.985	0.335								
			62.630	63.739		0.891	0.613	0.534	119.325	115.940	-3.385	3.348	6.90 grammes
		4.35 hrs.	76.580	77.195	0.615			0.4583	122.495	125.805	+3.310		
	stopped 18.09		68.648	68.114		0.534	0.575	0.1167				Mean	9.129 / 8.658 c.c. per amp-hr

27th Sept.

Two similar cells were made up with distilled water only using clean zinc electrodes. The transfer in this case was much more rapid.

No. of Obs.	Time	Interval	Weight of zinc Before grms	After grms	Gain grms	P.D.	Res.	Current	Mean	Q.	Transfer per second	Transfer per hour per amp-hr	Transfer per amp-hr grms
								Amp	Amp	Coulombs			
1	15.24.00	300 secs	109.979	131.360	21.482	0.478	12.765 Ω	0.03722			0.071647	2.057	7.406 grms
2	.25.00					0.470		0.03682					
3	.26.00		107.956	118.510	10.554	0.460		0.03606			0.035518	1.011	3.640
4	.27.00					0.450		0.03525					
5	.28.00					0.420		0.03290					
6	.29.00					0.390		0.03055	0.03348	1044			11.046

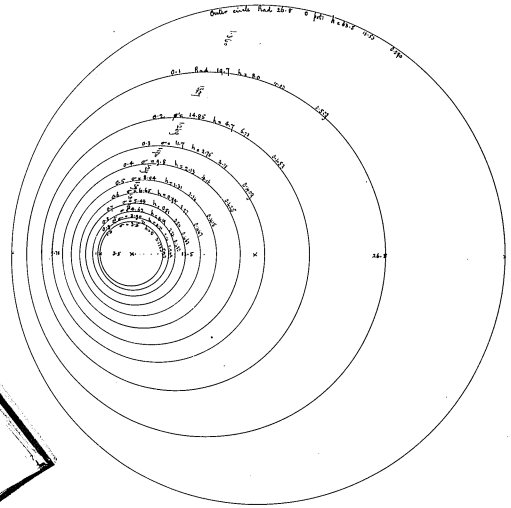
175

No. of Obs.	Time	Res. of G. coil	Res. added for balance	Ratio	Res. of gold at t° temp.	Res. of cable	Res. of cable for 1 cm.	Resistivity at 0°C.	R_t/r	Temp. of cable	Elevation of temp. of cable above mean	Ammeter current	P.D. on gold
1	14.00	2724	2317	1.8506	0.006250	3.007×10^{-3}	3.007×10^{-3} 4.176×10^{-4}	16.28 000	1.0714	18.6°		70	0.130
2	.10		2317	1.8506	0.2220	3.007 -	4.176 -		.	18.6°	0°	70	0.127
3	.12		2360									105	0.204
4	.25		2380									115	0.212
5	.35		2400									115	0.222
6	.42	2725	2410	1.8844		3.062 -	4.252 -		1.0914	23.4°	4.8°	120	0.225
7	.47		2460									150	0.278
8	15.00		2490										0.272
9	.12		2490										0.272
10	.19	2726	2490	1.9134		3.1095 -	4.318 -		1.111	27.6°	−9.0°	155	0.272
11	.26		2520									180	0.332
12	.41		2550										0.318
13	.56		2570	1.9426		3.1562 -	4.383 -		1.127	31.5°	12.9°	180	0.319
14	16.00		2620									220	0.381
15	.15		2640										0.381
16	.27		2690										0.389
17	.42	2727	2695	1.9884		3.2244 -	4.4777 -		1.152	37.4°	18.8°	240	0.379
18	.45		2770									250	0.462
19	.55		2860										0.463
20	17.07		2885										0.459
21	.12		2890	2.060		3.3472 -	4.6449 -		1.196	47.6	29°	250	0.457
22	.18		2970									285	0.523
23	.26		3010										0.518
24	.35		3100										0.524
25	.38		3115										0.523
26	.42	2728	3115	2.142		3.481 -	4.835 -		1.244	55.7	40.1	285	0.522
27	.43		3210									322	0.581
28	.50		3265										0.575
29	.53		3320										0.575
30	.56		3330										0.575
31	.58	2729	3340	2.224		3.614 -	5.019 -		1.291	69.5°	50.9°	322	0.578

Carrying Capacity of Siemens Cable contd. Sept. 11th

The 80,000 circular mil sample was buried in the trench was next tested. 42.5.5 diameter deep

Temp. of air	Potential current	Mean C	C^2	Watts per linear cm	Theoretical per linear cm	Cable temp. of shield	Temp. elevation of shield above mean	Cable temp. of conductor cable	Watts per deg. rise of shield $\frac{W}{\theta_{s-m}}$	Theoretical per deg. rise of shield
21.5°C.	80.0									
	78.15	79.	6,241	2.606×10^{-2}	6.205×10^{-2}			1.5°	4.963 $\times 10^{-2}$	1.181×10^{-2}
	123.1									
	134.5									
	136.6									
	138.5	135.2	18,279	7.772×10^{-2}	1.850×10^{-2}	19.4°	0.8°	4.0°	1.480×10^{-2}	3.523×10^{-2}
	171.1									
	167.4									
	167.4									
	167.4	168.3	28,325	1.223×10^{-1}	2.912×10^{-2}	21.4°	2.8°	6.2°	2.329×10^{-2}	5.546×10^{-2}
	198.1									
	195.7									
	195.7	196.5	38,612	1.692×10^{-1}	4.029×10^{-2}	23.0°	4.4°	8.6°	3.222×10^{-2}	7.673×10^{-2}
	234.5									
	234.5									
	233.9									
	233.3	234.1	54,803	2.454×10^{-1}	5.843×10^{-2}	25.4°	6.8°	12.0°	4.673×10^{-2}	1.113×10^{-2}
	284.3									
	284.9									
	282.5									
	281.3	283.2	80,202	3.729×10^{-1}	8.88×10^{-2}	29.3°	10.7°	18.3°	7.102×10^{-2}	1.691×10^{-2}
	321.9									
	318.8									
	322.5									
	321.9									
	321.3	322.0	103,684	4.991×10^{-1}	1.188×10^{-2}	34.5°	15.9°	24.2°	9.502×10^{-2}	2.263×10^{-2}
	357.6									
	357.9									
	355.7									
	355.7									
22°C.	355.7	355.7	126,522	6.354×10^{-1}	1.512×10^{-2}	38.5°	19.9°	31.0	1.21×10^{-1}	2.879×10^{-2}



Potential	σ	ratio	Discrepancy	h	$\frac{h}{\sigma}$	Mean	z
0.0	26.8	1:360	+ 0.135	15.53	0.580	0.477	0.103
0.1	14.7	1:327	+ 0.102	10.43	0.509		0.032
0.2	10.85	1:269	+ 0.044	6.73	0.453		− 0.024
0.3	8.07	1:194	− 0.031	4.78	0.409		− 0.068
0.4	6.65	1:219	− 0.006	4.16	0.425		− 0.052
0.5	5.66	1:209	− 0.016	3.24	0.415		− 0.062
0.6	4.93	1:211	− 0.014	2.97	0.447		− 0.030
0.7	4.37	1:183	− 0.037	2.54	0.463		− 0.014
0.8	3.92	1:185	− 0.040	2.32	0.480		+ 0.003
0.9	3.50	1:130	− 0.095	2.14	0.524		+ 0.072
1.0	3.25			2.03	0.524		+ 0.043
					5.250		

Measurements in relation to the problem of excentric cylinders.

A sheet of ~~iron~~ tinned iron 0.043 thick, was cut into a circle of 66 cms: in diameter. A strip 1.25 wide was cut from the center in a straight line to the circumference, making a slot in which the inner electrodes clamp bolt could travel. The disk was then tightly clamped between two massive brass plates fastened together by 12 bolts. The interior diameter of the rings was 53.6. These plates rings, fed at four points formed the outer circular electrode.

The inner electrode was a pair of short lengths of brass tube 7.0 in diam. one above and the other below the plate, in coaxial opposition. They were rigidly clamped together, and the upper tube was fed by two wires one at each side.

The pressure wire for the inner electrode was taken from a binding post screwed on to the shaft inside the brass tube. The

On the assumption that $V = A \log \sigma + B$

We have

$$1.0 = A \log 26.8 + B$$
$$0 = A \log 26.8 + B$$
$$1.0 = -A \log 7.656$$
$$= -A \times 0.8844$$
$$A = -1.131$$

$$1.0 - -1.131 \times$$
$$-B = -1.131 \times 1.428$$
$$B = 1.615$$

$$\therefore V = -1.131 \log \sigma + 1.615$$

$\sigma = 3.9$	$V = -1.131 \times 0.591 + 1.615$	$= -0.668 + 1.615$	$=$	0.947	obsd	0.9	0.047
$\sigma = 4.62$	0.6646	− 0.752		0.863	"	0.8	0.063
5.49	0.7396	0.836		0.779		0.7	0.079
6.65	0.8228	0.931		0.684		0.6	0.084
8.04	0.9053	1.024		0.591		0.5	0.091
9.8	0.9913	1.121		0.494		0.4	0.094
11.7	1.068	1.208		0.407		0.3	0.107
14.25	1.172	1.325		0.290		0.2	0.090
19.7	1.295	1.465		0.160		0.1	0.060
26.8	1.428	1.615		0.		0.	0

$$3.5 : 26.8 :: x : 13.5 + x$$
$$23.3x = 472.5$$
$$x = 20.3$$

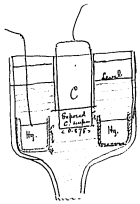
In working out these results, they indicate some fundamental error pervading the whole series, which has therefore to be abandoned. See p. 126

No. of Obs.	Time	Res. of G. coils	Res. added to coil for balance	Ratio	Res. of coil at temp	Res. of cable	Res. of cable per cm.	Resistivity @ 0°C	$\frac{R}{T}$	Temp. of Cable T	Elevation of temp. of cable from room	Ammeter current.	Pot. gradient.
1	0.25	2694 μω	1245	0.6841	0.00[illegible]55 @ 22°	1.118×10^{-3}	1.593×10^{-5}					unreliable	0.471
2	.40		1245									"	0.110
3	.55	2696	1245			1.118×10^{-3}	"					"	0.102
4	9.00		1245									"	0.120
5	.15	2698	1245	0.6842		1.112 -	"					"	0.121
6	.22		1242									"	0.237
7	.30		1240									"	0.239
8	.42		1240									"	0.238
9	.52	2700	1238	0.6856		1.114 -	1.546.					"	0.235
10	10.00		1220									"	0.326
11	.05		1215									"	0.333
12	.10		1212									"	0.332
13	.23	2702	1210	0.6906		1.122 -	1.557.					"	0.326
14	.25		1210									"	0.409
15	.30		1200									"	0.405
16	.47		1197									"	0.400
17	11.00	2704	1200	0.6927		1.126 -	1.563					"	0.399
18	.05		1195									"	0.471
19	.25	2706	1180	0.6964		1.132 -	1.571					"	0.472
20	.27		1170									"	0.567
21	.32		1158									"	0.562
22	.48		1135									"	0.557
23	.55		1135									"	0.557
24	12.18	2708	1135	0.7047		1.1145 -	1.589					"	0.557
25	.20		1120									"	0.648
26	.55	2710	1085	0.7142		1.1605 -	1.611					"	0.655
27	13.00		1065									"	0.744
28	.05		1050									"	0.740
29	.10		1030									"	0.740
30	.16		1020									"	0.740
31	.30	2711	1012	0.7281		1.183 -	1.642					"	0.730
32	.35		1000									"	0.782
33	.48		990									"	0.785
34	.58		967									"	0.778
35	14.10		960									"	0.770
36	.15	2711	960	0.7385		1.200 -	1.666					"	0.770

Carrying Capacity of Siemens Cable contd.

The 200,000 cm. mil. sample 720.5 cms. long was next tested, in the bench.

Temp. of Cu.	Potentl. current	Mean C.	C''	Watts per linear cm.	Therms per linear cm.	Cable temp. of shuttle	Temp. elevation of shuttle from room	Cable temp. of shuttle below conductor	Watts per sq. cm. of shuttle	Therms per sq. cm. of shuttle			Summer ratio of calc.
													1.4618
													1.4614
													1.4585
													1.4478
													1.4437
													1.4360
													1.4191
													1.4034
													1.3733
													1.3541



Particulars of McKenna and Weed Electrolytic Meter

This meter was examined in Allegheny City Pa. on the 22nd Sept. Several instruments were exhibited, but one in particular that had been in operation for several months. The load consisted of seven 50 cp lamps equivalent to 14 ordinary 16 cp each taking 0.85 amp. so that the total current was nearly 6 amp. The shunt consisted of two wires 0.035" in diam. G.S. in parallel and 34" = 2.833'. The res. of this wire being 0.198 ω per ft: = 0.1 ω per ft duplicate or 0.283 ω in all. With the meter intended for 10 amp, this would mean 2.8 volts drop at full load. The spool in circuit with the test cell had 11' of G.S. wire 0.010" = 11 × 2.4 ω = 26.4 ω res. The solution employed is water containing 5% by weight of HNO_3 and 5% Mercurous nitrate.

Heat tests with iron bobbin detailed on page 118.

The resistance of the coil was 1.657 ω @ 19°C

A current of $\frac{0.993}{0.09937}$ amp. was delivered through this coil for six hours

The temperature of the surrounding air was then 21.4°C.

The temperature on the brass bow of the coil, on top, was 58.5°C.

" " " center of the coil on the vertical side 61° and 60.2°

The mean temperature of the coil surface would probably be 60°C.

" " " elevation 38.6°C.

" resistance of the coil @ 0°C. would be. 1.~~[illegible]~~ =

" " " " @ load was 1.8685

" temp: elevation for 1.29~~[illegible]~~ = 62.7 = mean temp. of wire.

Current = 9.9925 amperes. C^2 = 98.51 C^2R = 186.5 watts.

Surface including ends 1600 sq. cms. = 0.1166 watt per sq. cm.

8.578 sq. cms per watt.

The entire surface of the drum was coated with japan varnish

The resistance at 21.8°C. was observed to be 1.863 ω. The insulation 120 ω

A current of about 5 amperes was passed through the coil from 10.30 to 23.0 clock. At that time the current was $\frac{0.4925}{0.09937}$ = 4.956 amp.

The P.D. on the drum 7.932 volts. The energy in the drum by this

= 38.52 watts

= 0.02407 " per sq. cm

= 41.54 sq. cms. per watt.

The temp. of the air was 20.5°C. at the time.

The temp: on top of cover = 29.8°C } Mean temp. 30°C

" " " side = 30.0°C at center. } 20.5

elevation 9.5°C.

The res: of drum by PD = 1.634 ω

" " " bridge = 1.645 ω

Mean = 1.64

Ratio = $\frac{1.64}{1.863}$ = 1.089 = 12.6°C.

200,000 C.M.L. section bunch 314.5 diameter

No. of Obs	Time	Res. of G. cable	Res. cable for balance	Ratio	Res. of grid for temp.	Res. of cable	Res. of cable per cm.	Resistivity	R/r	Temp. of cable	Elevation of cable below atmosphere	Charging current	P.D. on grid
1	13.20	2731	930	0.7446	0.0016552 @ 22°C.	1.212x10^3	1.6182x10^-3	1.89gx10^-6 per 0°C per cm.	1.072	18.1°C.		82	0.192
2	.31		930									82	0.168
3	.45		930	0.7446		1.212x10^3	1.6182x10^-3		1.072			82	0.150
4	.58		920									1444	0.261
5	.52		915									1444	0.245
6	14.05		907									1446	0.264
7	.16		905	0.7510		1.220x10^3	1.6293x10^-3		1.079	19.8°	1.7°	1444	0.264
8	.18		885									209	0.205
9	.30		880									200	0.329
10	.41		875									200	0.364
11	15.06		865	0.7595		1.234x10^3	1.7128x10^-3		1.09317	22.95°	4.85°	200	0.364
12	.10		830									260	0.265
13	.20		825									260	0.266
14	.42		812									262	0.460
15	.55		810	0.7712		1.253x10^3	1.739x10^-3		1.1054	27.0°	5.9°	262	0.458
16	.56		800									300	0.520
17	16.09		775									295	0.518
18	.24		775									300	0.530
19	.37		765									300	0.523
20	.48		765	0.7812		1.269x10^3	1.762x10^-3		1.123	30.5°	12.4°	300	0.521
21	.50		750									350	0.613
22	.55		730									350	0.610
23	17.00		710									350	0.600
24	.13		710	0.7936		1.290x10^3	1.790x10^-3		1.141	34.75°	16.7°	350	0.600
25	.15		680									400	0.700
26	.22		660									396	0.696
27	.29		640									396	0.700
28	.31		640	0.8100		1.316x10^3	1.8268x10^-3		1.164	40.2°	22.1°	396	0.705
29	.33		620									440	0.770
30	.40		615									438	0.775
31	.45		590									435	0.760
32	.47		580	0.8247		1.340x10^3	1.860x10^-3		1.1852	45.2°	27.1°	440	0.770
33	.49		570									-	0.800
34	.52		550									.	0.825
35	.55		540									.	0.822
36	.57		535									.	0.827
37	18.00	2727	525	0.8387		1.363x10^3	1.892x10^-3		1.206	50°	31.9°	.	0.827

Carrying Capacity of Siemens Cables. Sept. 26th (124)

Temp. of air.	Potential current	Mean C	C²	Watts per 1 cm. cm.	Thermal per 1 cm. cm.	Rater heat of sheath	Temp. elevation of sheath above air	Rater heat of sheath below air	Watts per sq. cm. of sheath	Thermal per sq. cm. of sheath			Increase ratio of cm.
22°C	87.4												1.31062
	91.1												
	92.3	90.3	8154	0.01371	0.00324			0.5°	1.983x10^-3	4.720x10^-3			1.31062
	164.9												
	163.1												
	165.5												
	162.5	164.0	26,929	0.04558	1.085x10^-2	18.1°	-	1.7°	6.892x10^-3	1.639x10^-2			1.33135
	218.5												
	220.9												
	224.0												
	224.0	222.1	49,325	0.07448	2.011x10^-2	19.75°	1.65°	3.2°	1.222x10^-2	3.248x10^-2			1.3168
	286.1												
	283.1												
	283.1												
	281.9	283.6	80,429	0.1399	3.331x10^-2	21.7°	3.6°	5.3°	2.023x10^-2	4.817x10^-2			1.2967
	320.0												
	318.8												
	326.2												
	321.9												
	320.7	321.5	103,362	0.1821	4.335x10^-2	23.6°	5.5°	6.9°	2.633x10^-2	6.269x10^-2			1.2802
	377.2												
	375.4												
	375.4												
	374.2	375.5	141,000	0.2524	6.008x10^-2	25.15°	7.05°	9.6°	3.650x10^-2	8.689x10^-2			1.2600
	436.9												
	434.4												
	433.8												
	433.9	434.7	188,964	0.3451	8.216x10^-2	27.1°	9.0°	13.10°	4.991x10^-2	1.188x10^-1			1.2345
	476.9												
	475.1												
	467.7												
	473.9	473.4	224,107	0.4168	9.926x10^-2	29.35°	11.25°	15.55°	6.027x10^-2	1.435x10^-1			1.2125
	492.3												
	509.6												
	509.6												
	509.0												
22°C.	509.0 17.2	509.4	259,468	0.4909	1.169x10^-1	31.35°	13.25°	18.60°	7.100x10^-2	1.691x10^-1			1.1923

Measurement of Power absorbed by Edison Battery Fan Motor.

27th Sept.

The motor was mounted in the boat, and the drive by a small Porter motor outside. The torque necessary to run the Edison motor with & without brushes on, and with or without field excitation was then observed.

No. of Obs.	Condition	Balance	Moment	Moment × 6·165	Energy per sec. Joules	Activity for 1200 r.p.m. watts	Loss in axle friction watts	Loss in brush friction	Loss in magnetic friction
1	Brushes up	50/00·4	20	$1·233 \times 10^5$	0·01233	0·247	0·247		
2	Brushes down	1·4	70	4·315 "	0·04315	0·863		0·616	
3	Field & Fe 3·5	2·3	115	7·09 "	0·0709	1·42			0·557
4									

These tests were repeated in a different way by mounting on the shaft of the Edison motor a pulley 1·55 ins. in radius. The weight that had to be placed in a bucket suspended over the pulley was noted as soon as rotation was produced under various conditions.

No. of Obs.	Condition	Total Wt lbs	Moment ins × grms.	Moment × 6·165	Energy per sec. Joules	Activity for 1200 r.p.m. watts	Loss in axle friction watts	Loss in brush friction	Loss in Magnetic friction
1	Brushes up	65 *	100·8	$6·21 \times 10^5$	0·0621	1·24	1·24		
2	- down	115	178·2	$1·098 \times 10^4$	0·11	2·2		0·96	
3	1 λ = 0·521 – Fe	125	193·8	1·195 "	0·12	2·4			
4	2 - 10 ..	137·5	213·2	1·314 "	0·13	2·6			
5	3 λ 1·54 ..	150	232·5	1·433 "	0·14	2·8			
6	4 - 1·98 ..	150	232·5	" "	0·14	2·8			
7	5 - 2·41 ..	154	239	1·474 "	0·15	3·0			
8	6 - 2·86 ..	161	249·5	1·538 "	0·15	3·0			0·80
9	9 - 4·28 ..	197	305	1·88 "	0·19	3·8			
10	12 - 5·16 ..	219	339·4	2·092 "	0·21	4·2			
							Total 3·0		

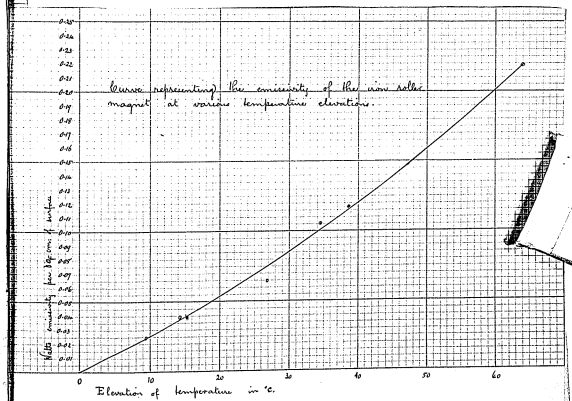
The second table gives starting frictions, the first running frictions. This accounts for the differences between their results.

A fan motor was set to work upon 40 cells of P Edison-Lalande battery which had been set up and in use for some little time. The test started at 1 p.m. on the 26th Sept. and the fan stopped at some time during the night of the 30/31st Oct. say 6 days 12 hrs. in operation. a 156 hours or perhaps 468 amp. hrs.

* A new fan motor on the 6th October had a smaller commutator, the diameter being reduced ½". Tested by the same pulley on the shaft, the starting moment with brushes up was 95 gms × 1·55 and with brushes down 115 gms × 1·55.

The battery was refreshed, and the fan again started. It ran for 120 hours continuously from 1 p.m. on the 4th Oct. to 12 noon on the 10th.

No. of Obs.	Date	Duration of current.	Direction of current on sides	Direction on periphery	P.D. Potentio	Res.	Reduced to by Potentio amps.	P.D. on shunt by Potentio volts	Res. of shunt but by Potentio ohms	Res. of shunt by bridge but ohms	Res. of shunt by bridge and ohms	Res.
1	Sept. 24th	12 hrs			0.993	0.09937	9.9925			1.868	1.5576 (a 19.4°)	1.3912
2	" 25th	12.5 "			0.4825	"	4.856	7.932	1.6314	1.6465	= 1.44629	1.431
3	" 27th	9. "			0.940	"	9.460	17.829	1.8855	1.882		1.3014
4	" 29th	14. "			0.750	"	7.546	13.977	1.8511	1.7975		1.2141
5	" 30th	14. "			1.244	"	12.52	27.944	2.2314	2.1750		1.5121
6	" 28th	13. "			0.605	"	6.09	10.37	1.703	1.723		1.4122
7	"											
8												



Temperature Elevation of Roller Magnet

cont'd. from p. 125
27th Sept.

Current of about 10 amp: maintained through magnet from 9 to 18 ccs.

P.D. on magnet at 18 ccs 17.829 volts
" " 0.1 in spiral . . . 0.940 " (.0099937 =)
Current through circuit 9.460 amp.
Resistance of drum by P.D. 1.885 Ω
" " " bridge 1.882 Ω
Temp: of surrounding air 19.5°C.
" " top of cover 53.0°C.
" " center of vertical side 55.2
Mean temp: of surface 54.°C
" elevation of " " 34.5°C.
Energy in drum. 168.7 watts
" per sq: cm: 0.1054 " per sq: cm.
Surface per unit energy. 9.486 sq: cms: per watts

Resist: of drum by bridge ccs	Resist. P.	Temp: of air °C	Temp: of air	Temperature on drum at sides	Temperature on drum at periphery	Mean Temp: of elevation	C²	C²R energy drum	Energy per sq: cms of surf	Temp: of copper by bridge	Temp: Elevation per watt per sq:	Emissivity per °C temp. elevation watts	
1.357 ω.	1.292	28.3	21.4°	60.6°	55.5	38.6°	98.51	186.5	0.1166	49.7°C.	3.31°	0.00302	plain
@ 16.45													
1.0446 ω	1.131	25.5°	20.5	39.0°	29.8°	9.4°	23.58	38.52	0.02407	34.°C.	3.905	0.002662	Japanned
	1.384	23.0°	19.5°	55.2	53.0	34.6	89.49	168.7	0.1054	72.5°	3.29.3	0.0030446	"
	1.241	39.4	18.6	46.3	44.4	26.8	56.94	102.5	0.06408	58.0°	4.18.2	0.002391	"
	1.561	20.0°	20.2°	86.5	81.2	64.0°	156.75	344.9	0.2156	125.0	2.92.3	0.0034145	"
	1.192	25.3°	21.4°	35.5	35.5	14.2	37.09	63.4	0.03965	46.7	3.58.1	0.002792	"

Measurements of Electro-osmose cont'd from p. 121.

27th depth.

The same two porous cells were used again in distilled water.

No. of Obs.	Time	Interval	Res. in cell.	Obs. res.	Current	Mean Current	Weight of cells.		Transfer	Transfer per amp.	Transfer per coulomb	Transfer per ampere	
					amp.	amp.	# 1	# 2	gm.	gm.	gm.		
1	17.01.00		12.65 ω	0.211	0.01668		106.702	102.742				0.0466	
2	.02.			0.206	0.01629								
3	.03.			0.209	0.01652				6.183 gm	4.50.0	1.0715	3.1858 gm	
4	.04.			0.2085	0.016448								
5	.05.			0.199	0.01573				10.978 gm	799.0	1.902	6.850	
6	.06.			0.187	0.01479							2.7766	
7	.07.			0.177	0.01400							0.2460	
8	.08.	4.20 secs		0.166	0.01313		107.660	102.559					
					0.012361		10.978	6.183					
9					0.01376								

The sp. res. of the water used in this test was then measured. An enforcing disk was filled to a depth of 8.35 cms. with distilled water. Two concentric electrodes were employed, one of 18 cm the other of 4.8 cm diam. with a pressure of 12.8 volts on the bath the current was $\frac{1.283}{61.82} = 0.02041$. The current per cm. of depth $= 0.003067$ ampere. With $128 - 2 = 126$ volts the res. $= 41.080$ ω.

$$\frac{e}{2\pi} \log_e \frac{a}{r} = 41.080 \quad \therefore \rho = \frac{6.283 \times 41.080}{\log_e 3.791} = \frac{6.283}{1.3326} \times 41.080 = 193.770$$

Sp. Res. $= 194.000$ ω per cubic cm.

Hookham's empirical formula for permanent magnetic circuits.

At pages 187-189 Vol 27 Phil Mag. 1889. Hookham gives an empirical relation for stable permanent magnetic circuits of hard steel. If L be the length of the air gap, A its area, l the length of the iron circuit, a its cross section.

Then $\frac{A}{L} \geqq 70 \frac{a}{l}$.

From this $\frac{L}{A} \leqq 0.0143 \frac{l}{a}$

But $\frac{L}{A} = G$ the reluctance of the airgap, so that this reduces to

$$G \leqq 0.0143 \frac{l}{a}$$

On the Determination of the sheath temperature of a bunched cable in air

If V = internal temp. of conductor (elevation)
v = external . . sheath (elevation)

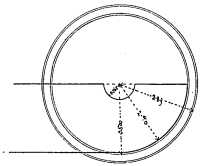
Then $\frac{V - v}{W} = v(\text{cmR} + c)$ where r = thermic resistance of insulator
σ = circumference of sheath
m = coeff. of radiation per surface
R = radiation (mean) per °c per square cm in watts
c = convection . . . per linear cm.

$$v(\text{cmR} + c + \tfrac{1}{r}) = \frac{V}{r}$$

$$v = \frac{V}{r(\text{cmR} + c + \frac{1}{r})}$$

$$= \frac{V}{1 + r(\text{cmR} + c)}$$

Full size plan of disk.



External Diameter of Disk = 2.25" 5.75
Int. " of rubber ring = 5.00
Outer Radius of pole face = 2.75
Inner " " " = 0.565
Polar area or semicircle = 9 sq. cms
Allowing 1 mm. fringe all round = 10.26 "
Outside " = 0.16 cm.
Reluctance of gap = 0.0156
Number of discs in side 52
" " wire = 50
Diameter " " = 0.010" d.s.c. 0.013" #20 B&S.
Mean length per turn = 0.5'
Total length of wire = 25'
res. of wire = 2.60 Ω by measurement 2.70 Ω.
Length under magnetic force = 25 x 2.0 = 50 cm.
Mean radius of section = 1.53 cms.
Weight of disk wound = 8.8 gms.
Cross section of magnet = 2.67 sq. cms.
Mean length of Mag. at = 37.5 cms.
Demagnetising force = 20.6/37.5 = 5.6 lines per sq. cm. = −H.

With the two phosphor bronze springs employed on the machine on the 3rd oct. the moment = 0.9025 cm. gms. at 65° = 280.006942 cm. gms. per degree of deviation. 0.039237 gives 36.6° so that 1 amp = 9178° = 63.71 cm. gms. = 2.6 62500 cm. dynes = 125,000 cm. dynes.

Trials of first model Edison Ammeter. 28th Sept.

A current of 0.1081 amp. produced a deflection of 66.8° = 618° per amp.
" " 0.0781 " " " 48.3° = 618.5° " "

A moment of 0.786 gms × 1.48 = 1.163 cm. gms. produced a deflection of 71.5°. 0.01666
" " 0.385 " × 1.88 = 0.7237 " " " " 53° 0.01653
" " " = 0.01655 " " " " 1° 0.01655
" " " = 16.23 cm. dynes " " " 1°
The moment for 10 amp = 6181.5° × 100,320 cm. dynes.
= 4,0,128 cm. dynes for each wire
= 20.064 " " " " cm. of wire
= 13/03 dynes per cm. of wire.
Mean field = 1310 C.G.S. lines per sq. cm.
Total useful field = 13,455 " " "
Useful flux through magnet = 4.985 " " " " "
P.D. across gap = 28.206 20 amp per pole.

The steel springs were taken out and replaced by spirals made up from phosphor bronze wire. The instrument was then recalibrated with the following results.

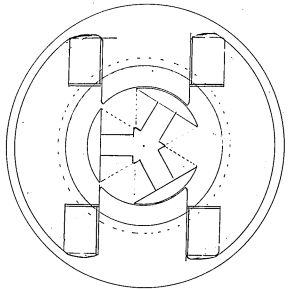
No. of Obs.	R. of Joint-wire in ohms	Lamps in series with 120 volts	PD across	Current	Deflection	Current per ° of Dfl	Weight		Mean	·125 Indication
1	12.66	2 λ	2.277	0.1799	124.5°	1.445×10⁻³	12	17.340		
2		3 λ	1.450	0.1145	85.5°	1.339	9	12.051		
3		4 λ	1.064	0.08404	63.0°	1.334	6	8.006		
4		5 λ	0.820	0.06477	48.0°	1.349	5	6.743		
5		6 λ	0.668	0.05277	39.0°	1.353	4	5.412	1.376 7/10	0.172057
							36	49.552		

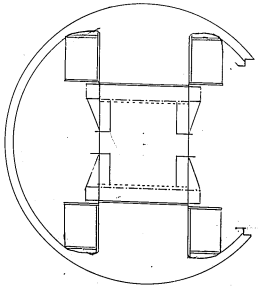
In order that 125° shall indicate 0.250 amp. the multiplying power of the shunt must be 1.453. The resistance of the instrument is 3.962 Ω @ 20.5°C. The shunt must be 3.962/0.453 = 8.746 Ω.

Particulars of the #2 Phoroplex Coil as recently constructed at Silvertown

Rubber flanges 2 5/8" x 2 5/8".
Tube of hard rubber 3/4" inside, 7/8" outside diam.
Outer flange 3 7/8".
Core wire 7" long. #18 B.&S. iron wire 0.04003".
Weight of core 147 gms = 0.3236 lb = 5.2 oz.
Length of wire in core 5.80" = 100 wire
Winding 17 layers of #20 B.W.G. d.s.c. 0.035" to 0.038" × 96 turns = 1632 turns.
Outside diam. 2 1/4". Each layer insulated with paper.
Weight of wire in coil 2.487 lbs.
Length " " " 669" = 5.63 ± 0.20 c. ✗
Mean diam 4.91" = 0.41'. = 4

Full size Sections.



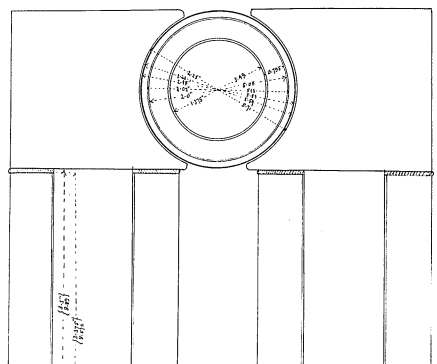


Winding: Field: 11 oz. # 15 B.W.G. d.c.c.
Arm: 2½ oz # 20 B.W.G. or 19 B.G. d.c.c.

Design for a Spherical Shell Battery Fan Motor.

Power = 2 watts.
Battery required = 3 Leclanché cells
EMF = 2·0 volts
Current = 2·0 amp.
Res: of battery = 0·1 ω
Drop in - = 0·2 volt
- - leads = 0·3 -
PD at motor = 1·5 -
EMF of motor = 1·2 -
Speed - - = 2100 r.p.m. = 35 r.p.s.
Type of motor spherical with glass window.
External diameter = 4·0"
Internal - of shell = 3·75"
Poles two, square, 1·275" sq. = 3·24 cms × 3·24
Polar bore = 1·675" 4·25 1·626" manufactured
Armature diam = 1·645" 4·18 1·581" manufactured
Face angle = 78°.
Side of base equilateral Δ = 0·5" 1·27
Breadth of armature tip = 0·3" 0·76 0·325" 0·775
Length - - = 0·95" 2·41 1·00 2·54
- - - face = 1·625" 4·13
Breadth - - = 1·025" 2·60.
Active Surface of one limit plate = 2·55 × 3·4 = 9·68 sq. cms. 2·55 × 2·5 = 8·93
Reluctance of gap (length) = 0·004
Entefer = 0·015" = 0·038
Minimum reluctance = 0·008
Maximum - = 0·012
Mean - = 0·01
Field winding = 70 turns of # 15 B.W.G. 0·072" d.c.c. & 0·085" in 2 spools of 35 turns each 7 × 5".
Mean turn = 0·6'
Total length of wire = 42'
- resistance = 0·084 ω @ 20° C.
- weight = 0·66 lb. = 11 oz. nearly.
Armature winding = 50 turns of # 20 B.W.G. or 19 B.G. 0·035" d.c.c. & 0·038" on each limb. = 5 mean layers of 10 turns each.
Length of mean turn = 3·5" = 0·25'
Total length of wire = 12·5' × 3 = 37·5'
- resistance = 0·316 ω
Mean Resistance between brushes = 0·070 ω. @ 20° C 0·075 ω.
Total weight of wire = 0·14 lb. = 2½ oz.
Cross section of one limb = (0·453 + 0·76 × 1·65) = 1·707 sq. cms. 0·775 × 2·5 = 1·970 sq. cm with tongue
MMF at 2 amp. = 88 × 2 = 176
Mean flux = 17,600
- intensity in arm = 10,310
- - in field = 3,120 (without leakage)
at constricted point
Mean EMF of armature = ¼ φ Nw = ¼ × 17,600 × 150 × 35 = 1·232 volt. @ 35 r.p.s.
Total res: of motor = 0·15 ω @ 20° C.
Drop in motor = 0·3 volt.
Res: of motor = 0·158 ω @ 20° C.
Diam of shaft in bearings = 0·155" = 0·394
Mass of arm = 225 g.
Diam: of brush pressure = 0·750
"s

Full sized plan of motor in section through core centres. Depth of pole faces 2"



Area of insulated core 6.925
" " " full magnet $\frac{50.140}{33.782}$ sq. ins
Bobbin contents of winding 184.8 sq. ins.

$d = 2.016\sqrt{\text{form} + \text{nwire}/\frac{\text{nwire}}{\text{diff}}}$
1670
+ 0.5560
0.5560
2.0170
2.0170

Armature 11 oz. # 26 B.W.G. 0.035" d.s.c. b 0.039"
Field 5 lbs. 9 oz # 11 B.G. 0.0907" d.s.c. b 0.099"

Design for a new motor meter for the Edison Patent Unit.

(132)

30th Sept.

A continuous current, shunt wound, Edison drum motor, with the armature vertical and running upon a jewel bearing.

Length of armature body	= 5.08	2"	
Diam. ext.	= 5.08	2"	Circ. = 6.28" × 2" = 5.04" available.
" int.	= 3.49	1.375"	
Cross section	= 4.06 sq. ins. on each side	= 8.07 in all. × 0.90 = 6.46 available.	
Polar bore diameter	= 5.71	2.25"	circ. = 17.94
Polar angle	= 136°		
" surface	= 34.4 sq. ins.		
Entrefer	= 0.215 ins.		
Total air reluctance	= $\frac{0.63}{34.4}$ × 2 = 0.0183.		
Winding	= 2 layers each of 120 turns + 20 extra	0.035" d.s.c. b 0.039"	Twenty pairs of 6 turns in each. Twenty fibre tubes of 0.020".
Total wire all round	= 240		
Length of one turn	= 0.9'		
Total length of wire	= 180'		
Total Weight	= 0.668 lb.		
" resistance	= 1.52 + ¾ = 0.19	effective @ 20°C.	Measured 0.191 = 29.4 Ω.
Commutator bars	= 20		
Diameter of commutator	= 1.0 ins = 0.4"		

Field winding	= # 11 B.G. 0.0907". s.c.c. b 0.099".	7 layer of 310 turns = 2170 turns
Mean diameter	= 1.105" circ. = 3.47"	= 0.472'
Total length	= 1ft 3' on each spool	= 2ft 6' in all
" weight	= 2.6 lbs.	
" resistance	= 0.282 @ 20°C.	0.323 = @ 60°C.
MMF per amp.	= 600	
Reluctance	= 0.02	
Flux per amp.	= 30,000.	

Exciting current in field at start = $\frac{29}{56}$ = 0.43
" " " armature = 0.57

With one amp. thro meter.
Flux with no residual mag = 12,900.
Torque at start. = $\frac{12,900 \times 0.027 \times 240}{6,265}$ = 29.6 cm-grms.

Cross-section of field core	= 6.7 sq. ins.	
Flux at 18,000 C.O.S.	= 120,600	produced at 4 amp.
Leakage factor	= 1.35	
Flux in armature	= 89,350.	
Density	= 13,820.	

EMF of armature at full flux = 90,000 × 240 = 216 × 10³ = 0.216 volt per sec. per sec.
At 2 volts generate EMF = 600 rpm.
" 1.05 " = 300 "

Thickness of armature (only) insulation	= 0.010"	
" of binding	= 0.010"	
Clearance	= 0.0250"	
Weight of armature	= 700 grms.	

On the Calculated Carrying Capacity of wires

No	Conductor	Cross Section mils	Section Ap. cms.	Resistance per cm. @ 0°C.	Resistance per cm. @ 55°C.	Radiation of first insulation	Thermal Resistance (Ry.1)	Radiation of second covering	Thermal Resistance (Ry.2)	Radiation of third covering	Thermal resistance Ry.3	Total Thermal Resistance	Diameter of exterior covering	Sectional
1	19/1000.0000	197.300	0.9996	1.05810⁻⁴	1.2772 / 1.0000	0.6667 / 0.5000 = 1.333	0.3000	1.25 / 1.00 = 1.17	0.1570	1.25 / 1.00 = 1.25 / 1.00 = 1.25 / 1.00 = 1.250	0.2198	98.22	4.86	15.9
2	19/1000.0000	259.200	1.3132	1.219	1.521	1.667 / 1.250 = 1.333	0.2790	1.50 / 1.00 = 1.50	0.1398	1.50 / 1.00 = 1.50 / 1.00 = 1.50 / 1.00 = 1.500	0.2250	76.87	5.16	16.2
3	37/1000.0000	373.810	1.8940	8.09810⁻⁵	1.055	1.25 / 1.00 = 1.250	0.2331	1.75 / 1.00 = 1.75	0.1265	1.75 / 1.00 = 1.75 / 1.00 = 1.75 / 1.00 = 1.750	0.1455	65.16	5.60	17.7
4	37/1000.0000	437.700	2.2172	7.916	9.246	1.25 / 1.00 = 1.250	0.09968	2.00 / 1.00 = 2.00	0.0679	2.00 / 1.00 = 2.00 / 1.00 = 2.00 / 1.00 = 2.000	0.0861	67.82	5.95	18.9
5	37/1000.0000	493.700	2.387	6.816	8.362	1.25 / 1.00 = 1.250	0.09985	2.25 / 1.00 = 2.25	0.0580	2.25 / 1.00 = 2.25 / 1.00 = 2.25 / 1.00 = 2.250	0.0604	62.79	6.29	19.9
6	37/1000.0000	594.000	3.012	5.401	6.63	1.25 / 1.00 = 1.250	0.07869	2.50 / 1.00 = 2.50	0.0461	2.50 / 1.00 = 2.50 / 1.00 = 2.50 / 1.00 = 2.500	0.07639	55.55	6.35	19.9
7	19/1000.0000	57.532	0.2913	5.57810⁻⁶	6.8468	1.25 / 1.00 = 1.250	0.2797	1.25 / 1.00 = 1.250	0.2326	1.25 / 1.00 = 1.25 / 1.00 = 1.25 / 1.00 = 1.250	0.3586	115.6	3.97	12.4
8	19/1000.0000	93.167	0.4715	3.860	4.778	1.25 / 1.00 = 1.250	0.2811	1.50 / 1.00 = 1.50	0.2346	1.50 / 1.00 = 1.50 / 1.00 = 1.50 / 1.00 = 1.500	0.4104	94.94	4.20	13.4
9	19/1000.0000	115.500	1.5846	2.779	3.411	1.50 / 1.00 = 1.500	0.2213	1.75 / 1.00 = 1.75	0.1904	1.75 / 1.00 = 1.75 / 1.00 = 1.75 / 1.00 = 1.750	0.4384	95.22	4.25	13.6
10	19/1000.0000	130.891	0.6632	2.453	3.012	1.75 / 1.00 = 1.750	0.1807	2.00 / 1.00 = 2.00	0.1215	2.00 / 1.00 = 2.00 / 1.00 = 2.00 / 1.00 = 2.000	0.5681	90.95	4.52	14.5
11	19/1000.0000	158.249	0.7450	2.054	2.522	1.75 / 1.00 = 1.750	0.1636	2.25 / 1.00 = 2.25	0.0912	2.25 / 1.00 = 2.25 / 1.00 = 2.25 / 1.00 = 2.250	0.6289	95.50	4.80	15.2
12	19/1000.0000	191.475	0.8688	1.8725	2.299	1.75 / 1.00 = 1.750	0.13673	2.50 / 1.00 = 2.50	0.0730	2.50 / 1.00 = 2.50 / 1.00 = 2.50 / 1.00 = 2.500	0.6935	77.04	4.60	14.6
13	37/1000.0000	237.800	1.6940	8.09810⁻⁵	1.055×10⁻⁴	1.25 / 1.00 = 1.250	0.11926	1.50 / 1.00 = 1.50	0.05614	1.50 / 1.00 = 1.500	0.08397	60.04	3.95	12.4
14	37/1000.0000	267.700	2.1672	7.916	9.2160	1.25 / 1.00 = 1.250	0.10721	1.75 / 1.00 = 1.750	0.05203	1.75 / 1.00 = 1.75 / 1.00 = 1.75 / 1.00 = 1.750	0.08492	57.97	3.97	12.4
15	37/1000.0000	437.700	2.387	6.816	8.362	1.75 / 1.00 = 1.750	0.10211	2.00 / 1.00 = 2.00	0.04532	2.00 / 1.00 = 2.00 / 1.00 = 2.00 / 1.00 = 2.000	0.08222	51.31	4.05	12.7
16	37/1000.0000	594.000	3.012	5.401	6.63	1.75 / 1.00 = 1.750	0.09707	2.50 / 1.00 = 2.50	0.04070	2.50 / 1.00 = 2.50 / 1.00 = 2.50 / 1.00 = 2.500	0.09981	51.57	4.50	14.1
17	37/1000.0000	749.000	3.799	4.282	5.257	1.75 / 1.00 = 1.750	0.08243	3.00 / 1.00 = 3.00	0.04179	3.00 / 1.00 = 3.00 / 1.00 = 3.00 / 1.00 = 3.000	0.10250	41.21	4.57	14.3
18	37/1000.0000	468.200	2.4628	3.216	4.072	1.75 / 1.00 = 1.750	0.08930	3.25 / 1.00 = 3.25	0.04269	3.25 / 1.00 = 3.25 / 1.00 = 3.25 / 1.00 = 3.250	0.10295	45.37	5.20	16.3
19	19/1000.0000	115.500	0.5856	2.779×10⁻⁶	3.4110⁻⁶	1.50 / 1.00 = 1.500	0.21590	1.75 / 1.00 = 1.750	0.15094	1.75 / 1.00 = 1.75 / 1.00 = 1.75 / 1.00 = 1.750	0.20025	93.96	4.98	9.7
20	19/1000.0000	130.891	0.6632	2.453	3.012	1.50 / 1.00 = 1.500	0.15503	2.00 / 1.00 = 2.00	0.09782	2.00 / 1.00 = 2.00 / 1.00 = 2.00 / 1.00 = 2.000	0.15423	78.10	3.07	9.6
21	19/1000.0000	158.249	0.7450	2.054	2.522	1.50 / 1.00 = 1.500	0.16197	2.25 / 1.00 = 2.25	0.07918	2.25 / 1.00 = 2.25 / 1.00 = 2.25 / 1.00 = 2.250	0.23383	75.6	3.21	10.0
22	19/1000.0000	191.475	0.8688	1.8725	2.299	1.50 / 1.00 = 1.500	0.13615	2.50 / 1.00 = 2.50	0.07315	2.50 / 1.00 = 2.50 / 1.00 = 2.50 / 1.00 = 2.500	0.26532	74.08	3.13	9.6
23	37/1000.0000	237.800	1.6940	1.4284	1.7494	1.50 / 1.00 = 1.500	0.11892	2.50 / 1.00 = 2.50	0.07591	2.50 / 1.00 = 2.50 / 1.00 = 2.50 / 1.00 = 2.500	0.24259	60.48	3.21	10.0
24	37/1000.0000	267.700	2.1672	1.239	1.521	1.50 / 1.00 = 1.500	0.12710	2.75 / 1.00 = 2.75	0.07057	2.75 / 1.00 = 2.75 / 1.00 = 2.75 / 1.00 = 2.750	0.24671	60.60	3.50	11.0
25	19/1000.0000	58.206	0.1330	1.22310⁻⁵	1.5224×10⁻⁵	1.75 / 1.00 = 1.750	0.28933	1.25 / 1.00 = 1.250	0.16175	1.25 / 1.00 = 1.25 / 1.00 = 1.25 / 1.00 = 1.250	0.25398	120.30	2.10	6.6
26	19/1000.0000	64.735	0.2115	7.692 10⁻⁶	9.4110⁻⁶	1.75 / 1.00 = 1.750	0.23325	1.50 / 1.00 = 1.50	0.07405	1.50 / 1.00 = 1.50 / 1.00 = 1.50 / 1.00 = 1.500	0.25652	100.1	2.30	7.2
27	19/1000.0000	77.532	0.2918	5.576	6.846	1.75 / 1.00 = 1.750	0.27110	1.75 / 1.00 = 1.750	0.05673	1.75 / 1.00 = 1.75 / 1.00 = 1.75 / 1.00 = 1.750	0.26781	117.0	2.70	8.5
28	19/1000.0000	91.609	0.4622	3.505	4.302	1.75 / 1.00 = 1.750	0.18156	2.00 / 1.00 = 2.00	0.04770	2.00 / 1.00 = 2.00 / 1.00 = 2.00 / 1.00 = 2.000	0.25522	89.4	2.71	8.5
29	19/1000.0000	57.532	0.2918	5.576	6.846	1.50 / 1.00 = 1.500	0.27110	1.50 / 1.00 = 1.500	0.08918	1.50 / 1.00 = 1.50 / 1.00 = 1.50 / 1.00 = 1.500	0.36689	109.2	2.45	7.7
30	19/1000.0000	115.500	0.5856	2.779	3.411	1.50 / 1.00 = 1.500	0.16107	2.00 / 1.00 = 2.00	0.07408	2.00 / 1.00 = 2.00 / 1.00 = 2.00 / 1.00 = 2.000	0.27727	77.6	2.81	8.9
31	1/1000.0000	2.581	0.01308	1.34×10⁻⁴	1.527	1.25 / 1.00 = 1.250	0.51168	1.25 / 1.00 = 1.250	0.19201	1.25 / 1.00 = 1.25 / 1.00 = 1.25 / 1.00 = 1.250	0.71369	143.5	1.26	3.9
32	1/1000.0000	2.581	0.01308	1.34	1.527	1.25 / 1.00 = 1.250	0.61972	1.50 / 1.00 = 1.50	0.12743	1.50 / 1.00 = 1.50 / 1.00 = 1.50 / 1.00 = 1.500	0.74115	225.7	1.60	5.0
33	1/1000.0000	4.109	0.02077	7.83×10⁻⁵	9.617	1.50 / 1.00 = 1.500	0.27776	1.75 / 1.00 = 1.750	0.13181	1.75 / 1.00 = 1.75 / 1.00 = 1.75 / 1.00 = 1.750	0.82165	182.6	1.73	5.4
34	1/1000.0000	6.529	0.03308	4.918	6.037	1.75 / 1.00 = 1.750	0.24173	2.00 / 1.00 = 2.00	0.10623	2.00 / 1.00 = 2.00 / 1.00 = 2.00 / 1.00 = 2.000	0.87809	172.0	1.70	5.3
35	1/1000.0000	10.384	0.05261	3.092	3.796	1.75 / 1.00 = 1.750	0.33102	2.25 / 1.00 = 2.25	0.09237	2.25 / 1.00 = 2.25 / 1.00 = 2.25 / 1.00 = 2.250	0.97115	185.9	1.92	6.0
36	1/1000.0000	16.512	0.07367	1.945	2.387	1.75 / 1.00 = 1.750	0.33985	2.50 / 1.00 = 2.50	0.09063	2.50 / 1.00 = 2.50 / 1.00 = 2.50 / 1.00 = 2.500	0.99061	130.6	1.94	6.1
37	1/1000.0000	4.109	0.02077	7.934	9.617	1.25 / 1.00 = 1.250	0.37676	1.50 / 1.00 = 1.500	0.22608		.6028	165.7	1.38	4.3
38	1/1000.0000	6.529	0.03308	4.918	6.037	1.25 / 1.00 = 1.250	0.30793	1.75 / 1.00 = 1.750	0.19868		.5761	151.7	1.39	4.3
39	1/1000.0000	10.384	0.05261	3.092	3.796	1.25 / 1.00 = 1.250	0.37016	2.00 / 1.00 = 2.00	0.19835		.5685	156.3	1.50	4.7
40	1/1000.0000	16.512	0.07367	1.945	2.387	1.25 / 1.00 = 1.250	0.33105	2.25 / 1.00 = 2.25	0.17314		.5042	138.6	1.52	4.7
41	1/1000.0000	26.240	0.1330	1.225	1.502	1.25 / 1.00 = 1.250	0.27990	2.50 / 1.00 = 2.50	0.16820		.4490	123.2	1.65	5.1
42	1/1000.0000	41.735	0.2115	7.69×10⁻⁶	9.4110⁻⁶	1.25 / 1.00 = 1.250	0.24361	2.75 / 1.00 = 2.75	0.16909		.4123	113.3	1.80	5.7
43	19/1000.0000	259.200	1.3132	1.239×10⁻⁵	1.5210⁻⁵	1.25 / 1.00 = 1.250	0.10789	1.25 / 1.00 = 1.250	0.09407		.20196	55.6	2.84	9.0
44	19/1000.0000	373.810	1.8940	8.09×10⁻⁵	1.055	1.25 / 1.00 = 1.250	0.11461	1.50 / 1.00 = 1.500	0.07700		.19161	52.69	2.98	9.4
45	37/1000.0000	437.700	2.1672	7.916	9.2160	1.25 / 1.00 = 1.250	0.09765	1.75 / 1.00 = 1.750	0.06521		.16287	44.66	2.77	8.7
46	37/1000.0000	594.000	2.387	6.816	8.378	1.25 / 1.00 = 1.250	0.09641	2.00 / 1.00 = 2.00	0.05622		.15113	41.40	3.00	9.4
47	37/1000.0000	749.000	3.799	4.282	5.257	1.25 / 1.00 = 1.250	0.08324	2.25 / 1.00 = 2.25	0.04614		.13265	36.47	3.11	9.8
48	37/1000.0000	468.200	2.4628	3.216	4.072	1.25 / 1.00 = 1.250	0.08930	2.50 / 1.00 = 2.50	0.04619		.13609	37.42	3.40	10.7

List of Samples of Siemens Cables

manufactured by the

Edison General Electric Company.

Explanation of Signs: C - Cable; L - Lead; A - Asphalt; I - Iron Armoring; W - Wire Armoring; CL - Bare Lead Cable; CLA - Asphalted Lead Cable; CLAI - Iron Armored Lead Cable; CLAW - Wire-Armored Lead Cable; CLAIW - Iron and Wire Armored (Submarine) Cable; CM - Sectional Area of Conductor in Circular Mils.

Telegraph Cables Submarine.

78 C.L.A. 18 B.W.G.	79 C.L.A. 18 B.&S.
80 C.L.A. 5/16 B.W.G.	81 C.L.A.W. 5/16 B.W.G.
82 C.L.A. 6/16 B.W.G.	83 C.L.A.W. 6/16 B.W.G.
84 C.L.A. 7/16 B.W.G.	85 C.L.A.W. 7/16 B.W.G.
86 C.L.A. 7/18 B.W.G.	87 C.L.A.W. 7/18 B.W.G.
88 C.L.A. 7/18 B.W.G.	89 C.L.A.W. 7/18 B.W.G.
90 C.L.A. 7/18 B.W.G.	91 C.L.A.W. 7/18 B.W.G.
92 C.L.A. 7/18 B.W.G.	93 C.L.A.W. 7/18 B.W.G.
94 C.L.A.W. 7/18 B.&S.	95 C.L.A. 7/18 B.&S.
96 C.L.A.W. 7/18 B.&S.	97 C.L.A. 7/18 B.&S.
98 C.L.A.W. 7/18 B.&S.	99 C.L.A. 7/18 B.&S.
100 C.L.A.W. 7/18 B.&S.	101 C.L.A. 7/18 B.&S.
102 C.L.A.W. 7/18 B.&S.	103 C.L.A. 7/18 B.&S.
104 C.L.A.W. 7/18 B.&S.	105 C.L.A. 7/18 B.&S.
106 C.L.A.W. 7/18 B.&S.	107 C.L.A. 7/18 B.&S.
108 C.L.A.W. 7/18 B.&S.	109 C.L.A. 7/18 B.&S.

Light and Power Cables.

Tested for 2000 Volts Continuous Current.

1 CLAIW. 300000 C.M.	2 CLAIW. 250000 C.M.	3 CLAIW. 350000 C.M.	4 CLAIW. 400000 C.M.	5 CLAIW. 500000 C.M.
6 CLAIW. 600000 C.M.	7 CLAIW. 80000 C.M.	8 CLAIW. 120000 C.M.	9 CLAIW. 100000 C.M.	10 CLAIW. 150000 C.M.
11 CLAIW. 180000 C.M.	12 CLAIW. 210000 C.M.	13 CLAI. 350000 C.M.	14 CLAI. 400000 C.M.	15 CLAI. 500000 C.M.
16 CLAI. 600000 C.M.	17 CLAI. 800000 C.M.	18 CLAI. 1000000 C.M.	19 CLAI. 1000000 C.M.	20 CLAI. 1200000 C.M.
21 CLAI. 1500000 C.M.	22 CLAI. 1800000 C.M.	23 CLAI. 2000000 C.M.	24 CLAI. 2500000 C.M.	25 CLAW. *6 B.&S.
26 CLAW. *4 B.&S.	27 CLAI. 300000 C.M.	28 CLAI. 50000 C.M.	29 CLAI. 500000 C.M.	30 CLAI. 100000 C.M.
31 CLA. *19 B.&S.	32 CLAW. *16 B.&S.	33 CLAW. *14 B.&S.	34 CLAW. *12 B.&S.	35 CLAW. *10 B.&S.
36 CLAW. *8 B.&S.	37 C.L.A. *14 B.&S.	38 C.L.A. *12 B.&S.	39 C.L.A. *10 B.&S.	40 C.L.A. *8 B.&S.
41 C.L.A. *6 B.&S.	42 C.L.A. *4 B.&S.	43 C.L.A. 250000 C.M.	44 C.L.A. 350000 C.M.	45 C.L.A. 400000 C.M.
46 C.L.A. 500000 C.M.	47 C.L.A. 600000 C.M.	48 C.L.A. 1000000 C.M.	49 C.L.A. 50000 C.M.	50 C.L.A. 120000 C.M.
51 C.L.A. 100000 C.M.	52 C.L.A. 150000 C.M.	53 C.L.A. 180000 C.M.	54 C.L.A. 200000 C.M.	55 C.L. 200000 C.M.
56 C.L. 350000 C.M.	57 C.L. 400000 C.M.	58 C.L. 500000 C.M.	59 C.L. 600000 C.M.	60 C.L. 1000000 C.M.
61 C.L. 50000 C.M.	62 C.L. 100000 C.M.	63 C.L. 120000 C.M.	64 C.L. 150000 C.M.	65 C.L. 150000 C.M.
66 C.L. 250000 C.M.	67 C.L. *18 B.&S.	68 C.L. *20 B.&S.	69 C.L. *20 B.&S.	70 C.L. 60000 C.M.
71 C.L. 80000 C.M.	72 C.L. 80000 C.M.	73 C.L. *16 B.&S.	74 C.L. *14 B.&S.	75 C.L. *12 B.&S.
76 C.L. *10 B.&S.				

Telegraph Cables Underground.

110 C.L. 7/18 B.&S.	111 C.L. 7/18 B.&S.
112 C.L.A. 7/18 B.&S.	113 C.L.A. 7/18 B.&S.
114 C.L.A.W. 7/18 B.&S.	115 C.L.A.W. 7/18 B.&S.

77
C.L.A.I.
3-conductor cable.
2-200000 C.M.
1-100000 C.M.

Telephone Cables.

116 C.L.A.I. 50 pairs *18 B.&S.	117 C.L.A. 50 pairs *18 B.&S.	118 C.L. 50 pairs *18 B.&S.

Samples of Siemens Cable for electric light distribution.

Diam. Centimetres	Sectional area in mm.	Diam. inches	Sectional area in mm.	Diam. inches	Sectional area in mm.	Diam. inches	Sectional area in mm.
1.06	15.57						
5.16	16.14						
5.60	17.70						

Samples of Siemens Cable for electric light distribution.

Diameter in inches	Sectional area in mm.	Sectional area in mm.	θ_1	Resistance per mile in ohms W_1	Resistance per mile in ohms $C_1^{\pm}$	C_1	Correction for temp. θ_1	Resistance per mile at temp. θ_2	Total resistance per mile in ohms	Temp. θ_2	W_2	$C_2^{\pm}$	C_2
0.2834	141,910	376.5	12.5	0.1147	79,900	266.3	0.00115	0.00116	0.01869	9.5° 65	0.1757	97,900	296.5
0.3152	213,930	462.4	12.5	0.1626	106,915	327.	-	0.01799	0.01974	16° 15	0.1951	128,300	358.2
0.3916	362,700	603.0	12.5	0.1918	181,850	426.4	-	0.0197	0.02145	10.5° 16.5	0.2225	234,700	484.5
0.4087	400,000	632.5	12.5	0.18135	200,000	447.3	-	0.02014	0.02219	10.5° 15	0.2212	240,000	489.9
0.4582	475,800	690.0	12.5	0.1991	237,900	487.8	-	0.02135	0.02310	10.5° 16.5	0.2357	281,600	530.7
0.5510	675,400	821.9	12.5	0.2250	337,700	581.1	-	0.02214	0.02389	10.5° 15.5	0.2565	396,900	630.0
0.163	31,570	177.7	12.5	0.1082	15,795	125.7	-	0.01324	0.01559	8.9 16.5	0.1393	20,350	142.7
0.256	53,320	230.9	12.5	0.1263	26,660	163.3	-	0.01465	0.01660	9.5 15.5	0.1566	33,060	181.9
0.325	76,980	277.4	12.5	0.1312	38,490	196.2	-	0.01492	0.01677	9.7 15.5	0.1607	47,100	217.1
0.368	91,250	302.1	12.5	0.1374	45,625	213.6	-	0.01576	0.01751	9.6 15.4	0.1693	56,200	237.1
0.418	103,800	322.2	12.5	0.1397	51,900	227.8	-	0.01611	0.01784	9.0 16.0	0.1675	66,120	257.7
0.472	134,700	373.8	12.5	0.1645	67,850	260.3	-	0.01660	0.01779	10.5 14.5	0.1763	81,650	284.7
0.565	204,100	452.3	12.5	0.2083	102,400	320.3	-	0.01377	0.01552	12.9 12.1	0.2015	91,000	302.1
0.618	268,600	518.6	12.5	0.2437	134,300	366.6	-	0.01385	0.01560	13.1 11.9	0.2056	273,900	523.3
0.732	382,300	618.1	12.5	0.2637	191,150	437.6	-	0.01412	0.01587	12.9 12.1	0.2183	266,900	516.9
0.847	531,200	728.8	12.5	0.2933	266,600	516.5	-	0.01569	0.01744	13.2 11.8	0.2288	346,100	587.5
0.967	713,200	844.4	12.5	0.3034	356,600	597.5	-	0.01600	0.01779	13.4 10.6	0.2372	439,200	662.4
1.111	935,000	967.0	12.5	0.3156	467,500	683.8	-	0.01613	0.01788	13.1 11.9	0.2422	600,100	775.0
0.244	46,100	214.7	12.5	0.1332	23,050	151.8	-	0.01209	0.01421	11.7 13.3	0.1417	31,540	177.6
0.303	66,300	257.4	12.5	0.1601	33,150	182.0	-	0.01271	0.01476	12.7 12.3	0.1575	32,290	179.7
0.347	81,200	285.0	12.5	0.1624	40,600	201.5	-	0.01320	0.01525	12.6 12.4	0.1640	45,040	212.3
0.461	137,500	370.9	12.5	0.1851	68,750	262.2	-	0.01092	0.01267	13.5 12.5	0.1581	68,750	262.2
0.580	194,100	440.6	12.5	0.1940	97,050	311.5	-	0.0120	0.0145	13.6 11.4	0.1769	85,480	292.5
0.726	271,200	520.9	12.5	0.2063	135,600	368.5	-	0.01221	0.01396	13.5 11.5	0.1798	124,700	353.1
0.275	13,840	117.6	12.5	0.1039	6920	83.2	-	0.00721	0.00907	12.0 13.0	0.1081	7,940	89.2
0.398	26,450	162.6	12.5	0.1249	13,225	115.0	-	0.00802	0.00977	12.6 12.4	0.1229	13,200	114.5
0.237	31,210	176.7	12.5	0.1069	15,605	124.9	-	0.00941	0.01116	11.9 14.1	0.1205	16,000	126.7
0.297	65,010	255.0	12.5	0.1398	32,505	180.3	-	0.00945	0.01120	12.5 12.5	0.1398	32,505	180.3
0.290	33,450	182.9	12.5	0.1146	16,725	129.3	-	0.00955	0.01103	11.8 13.2	0.1209	17,650	132.9
0.322	94,400	307.3	12.5	0.1611	47,220	217.2	-	0.00980	0.01155	12.2 12.8	0.1521	22,960	151.0
0.392	84,665	291.1	12.5	0.0646	42.33	20.6	-	0.00642	0.00815	11.4 13.6	0.0703	4603	21.5
0.108	725.5	26.9	12.5	0.0504	362.8	19.1	-	0.00533	0.00733	9.4 15.6	0.0691	452.7	21.3
0.159	1424	37.7	12.5	0.0665	712.	26.7	-	0.00604	0.00779	10.3 14.7	0.0805	1028.	32.1
0.253	2407	49.1	12.5	0.0727	1204.	34.7	-	0.00592	0.00767	10.3 14.2	0.0824	1368.	37.0
0.340	4847	69.6	12.5	0.0920	2424.	49.2	-	0.00689	0.00866	11.6 13.4	0.0986	2597	51.0
0.414	8076	89.5	12.5	0.0957	4038	63.3	-	0.00677	0.00853	11.9 13.1	0.1003	4202	64.8
0.509	1569	39.6	12.5	0.0755	785	28.0	-	0.00482	0.00657	12.0 13.0	0.07815	815.8	28.5
0.648	2730	52.2	12.5	0.0824	1365	36.9	-	0.00485	0.00660	12.5 12.5	0.0824	1365	36.9
0.5719	4212	64.9	12.5	0.0900	2106	45.9	-	0.00523	0.00695	12.0 13.0	0.08316	2193	46.8
0.8004	7656	86.9	12.5	0.0942	3778	61.5	-	0.00520	0.00708	12.6 12.4	0.08946	3748	61.2
0.2030	13320	116.3	12.5	0.1015	6760	82.2	-	0.00575	0.0750	13.0 12.0	0.09712	6458	80.5
0.2109	23370	152.9	12.5	0.1104	11685	108.1	-	0.00627	0.00802	13.1 11.9	0.10500	11240	105.5
0.3446	29,800	542.7	12.5	0.2248	147,000	384.4	-	0.00999	0.01174	15.1 9.9	0.1700	177,000	342.1
0.4715	449,800	670.7	12.5	0.2373	224,900	474.2	-	0.00969	0.01142	15.6 9.4	0.17844	169,100	411.3
0.5979	740,000	860.6	12.5	0.2800	370,000	610.7	-	0.00966	0.01142	16.5 8.5	0.1903	285,500	534.4
0.5020	509,100	714.0	12.5	0.2510	299,550	547.3	-	0.0195	0.01260	15.6 9.4	0.1928	230,200	479.8
0.6556	1,130,400	1062.0	12.5	0.3428	652,000	807.4	-	0.01033	0.01268	18.8 6.2	0.2523	480,000	692.8
0.6680	1,661,000	1281.0	12.5	0.3340	828,500	910.8	-	0.01534	0.01709	15.2 9.8	0.2620	643,700	802.3

Calculated Carrying Capacities of Samples of Siemens Cable from Schenectady Works

No.	Conductor	Cross Circ. mil	Section Sq. cms	Res. per cm @ 0°C	Res. per cm @ 55°C	Diameters of 1st coat $\frac{D}{d}$	1st coat Thermal res. $\log_e \frac{D}{d}$	Diameters of 2nd coat $\frac{D}{d}$	2nd coat Thermal res.	3rd Coat Diameter	3rd Coat Thermal Res.	Total Thermal res. (274.9)	Diam. of exterior sheath	Surface ...
49	7 #12 BWG	83,167	0.4215	3.860×10^{-6}	4.738×10^{-6}	$\frac{1.28}{0.78} = 1.641$	0.21511	$\frac{1.99}{1.76} = 1.131$	0.05346	0.26857		73.84	1.99	6.25
50	19 #14 BWG	130,891	0.6632	2.453 "	3.012 "	$\frac{1.51}{1.05} = 1.438$	0.15776	$\frac{2.32}{1.82} = 1.275$	0.10551	0.26327		72.36	2.32	7.29
51	7 #8 BS 0.1285	115,584	0.5856	2.778 "	3.411 "	$\frac{1.44}{0.92} = 1.565$	0.19451	$\frac{2.23}{1.70} = 1.312$	0.11793	0.31244		85.89	2.23	7.01
52	19 #11 BS 0.0907	156,294	0.7920	2.054 "	2.522 "	$\frac{1.61}{1.11} = 1.451$	0.16167	$\frac{2.44}{2.07} = 1.179$	0.07151	0.23318		64.10	2.44	7.67
53	19 #13 BWG 0.095	171,475	0.8688	1.8725 "	2.299 "	$\frac{1.65}{1.19} = 1.387$	0.14208	$\frac{2.48}{2.00} = 1.20$	0.07918	0.22126		60.83	2.48	7.79
54	19 #10 BS 0.102	197,300	0.9996	1.628 "	1.999	$\frac{1.75}{1.32} = 1.326$	0.12254	$\frac{2.59}{2.09} = 1.239$	0.09307	0.21561		59.28	2.59	8.14
55	19 #10 BS 0.102	197,300	0.9996	1.628 "	1.999	$\frac{1.78}{1.38} = 1.290$	0.11059			0.11059		30.40	2.10	6.60
56	36 #10 BS 0.102	373,810	1.8940	8.570×10^{-7}	1.055×10^{-6}	$\frac{2.36}{1.85} = 1.276$	0.10585			0.10585		29.10	2.72	8.55
57	36 #12 BWG 0.109	427,720	2.1672	7.506 "	9.216×10^{-7}	$\frac{2.34}{1.87} = 1.251$	0.09726			0.09726		26.74	2.77	8.70
58	36 #9 BS 0.114	471,200	2.387	6.816	8.378 "	$\frac{2.5}{2.0} = 1.25$	0.07691			0.07691		26.65	2.80	8.80
59	36 #7 BS 0.144	749,500	3.799	4.282 "	5.257 "	$\frac{3.08}{2.65} = 1.162$	0.06521			0.06521		17.93	3.52	11.06
60	36 #? 0.164	968,200	4.906	3.316 "	4.072 "	$\frac{3.55}{2.89} = 1.228$	0.08920			0.08920		24.52	3.95	12.41
61	7 #12 BWG 0.109	83,167	0.4215	3.860 "	4.738 "	$\frac{1.28}{0.78} = 1.641$	0.21511			0.21511		59.14	1.76	5.53
62	7 #8 BS 0.1285	115,584	0.5856	2.778 "	3.411	$\frac{1.44}{0.92} = 1.565$	0.19451			0.19451		53.48	1.80	5.66
63	19 #14 BWG 0.083	130,891	0.6632	2.453 "	3.012 "	$\frac{1.51}{1.05} = 1.438$	0.15776			0.15776		43.37	1.82	5.72
64	19 #13 BWG 0.095	171,475	0.8688	1.8725 "	2.299 "	$\frac{1.63}{1.19} = 1.456$	0.16316			0.16316		44.86	2.00	6.25
65	19 #11 BS 0.0907	156,294	0.7920	2.054 "	2.522 "	$\frac{1.61}{1.11} = 1.451$	0.16167			0.16167		44.44	2.07	6.50
66	18 #11 BWG 0.120	259,200	1.3132	1.239 "	1.521 "	$\frac{2.00}{1.56} = 1.282$	0.10789			0.10789		29.66	2.30	7.23
67	1 #8 BS 0.128	16,512	0.08367	1.945×10^{-5}	2.387×10^{-5}	$\frac{0.75}{0.35} = 2.143$	0.33102			0.33102		91.00	1.02	3.21
68	1 #6 BS 0.162	26,244	0.1330	1.2235 "	1.502 "	$\frac{0.80}{0.42} = 1.905$	0.27990			0.27990		76.96	1.12	3.52
69	1 #4 BS 0.204	41,738	0.2115	7.692×10^{-6}	9.444×10^{-6}	$\frac{0.89}{0.52} = 1.711$	0.23325			0.23325		64.13	1.28	4.02
71	7 #11 BS 0.091	57,582	0.2918	5.576 "	6.846 "	$\frac{1.12}{0.6} = 1.567$	0.27114			0.27114		74.55	1.49	4.68
70	7 #13 BWG 0.095	63,175	0.3202	5.208	6.394 "	$\frac{1.17}{0.71} = 1.647$	0.21669			0.21669		59.57	1.47	4.62
72	7 #12 BWG 0.109	83,167	0.4215	3.860 "	4.738 "	$\frac{1.28}{0.78} = 1.641$	0.21511			0.21511		59.13	1.76	5.53
73	1 #16 BS 0.0508	2,581	0.01308	1.244×10^{-4}	1.527×10^{-4}	$\frac{0.52}{0.16} = 3.250$	0.51188			0.51188		140.7	0.81	2.545
74	1 #14 BS 0.064	4,109	0.02077	7.834×10^{-5}	9.617×10^{-5}	$\frac{0.50}{0.21} = 2.381$	0.37676			0.37676		103.6	0.82	2.55
75	1 #12 BS 0.081	6,529	0.03308	4.918 "	6.037 "	$\frac{0.58}{0.21} = 2.762$	0.44122			0.44122		121.3	0.90	2.83
76	1 #10 BS 0.102	10,384	0.05261	3.092 "	3.796 "	$\frac{0.68}{0.29} = 2.345$	0.37014			0.37014		100.8	0.95	2.99
77	11 #4 BWG 0.238; 24 #9 BWG 0.148	623,080; 625,216	3.157; 3.168	5.137×10^{-7}; 5.155 "	6.306×10^{-7}; 6.325 "	0.29; $\frac{3.41}{2.80} = 1.218$	0.08565	$\frac{4.65}{4.10} = 1.134$	0.05461	$\frac{5.6}{5.2} = 1.077$; $\frac{?}{?} = 1.065$	0.05461; 0.03222; 0.02776; 0.11459	23.55; 31.50; 31.50	6.10	19.17

θ	W	C^2	C	θ_1	W_1	C_1^2	C_1	Convection per cm	Radiation per °C	Total emission	v	θ_2	W_2	C_2^2	C_2
25°	0.3386	73,800	271.7	12.5°	0.1693	36,900	192.1	0.00175	0.00694	0.00869	15.2	9.8	0.1328	28,020	167.4
-	0.3455	114,700	338.7	-	0.1727	57,350	239.6	-	0.00809	0.00984	14.6	10.4	0.1437	47,700	218.4
-	0.2911	85,360	292.1	-	0.1456	42,670	206.6	-	0.00778	0.00953	13.7	11.3	0.1316	38,570	196.4
-	0.3901	154,700	393.3	-	0.1950	77,350	278.1	-	0.00851	0.01026	15.1	9.9	0.1545	61,260	247.5
-	0.4110	178,800	422.9	-	0.2055	89,400	299.0	-	0.00865	0.01040	15.3	9.7	0.1595	69,360	263.4
-	0.4218	211,000	459.4	-	0.2109	105,500	324.8	-	0.00903	0.01078	15.3	9.7	0.1637	81,860	286.1
-	0.8224	411,400	641.4	-	0.4112	205,700	453.5	-	0.00733	0.00908	19.6	5.4	0.1776	88,880	298.1
-	0.8594	924,600	962.5	-	0.4297	462,300	682.1	-	0.00948	0.01123	18.8	6.2	0.2131	202,000	449.4
-	0.9351	1,015,000	1008.	-	0.4676	500,750	707.7	-	0.00965	0.01140	19.2	5.8	0.2170	235,400	485.2
-	0.9382	1,120,000	1058.	-	0.4691	560,000	748.3	-	0.00977	0.01152	19.1	5.9	0.2214	264,200	513.8
-	1.394	2,651,000	1628	"	0.697	1,325,500	1151.0	-	0.01227	0.01302	20.3	4.7	0.2621	498,500	706.0
-	1.021	2,506,000	1583	-	0.5105	1,253000	1119.0	-	0.01377	0.01552	18.1	6.9	0.2817	691,800	831.7
-	0.4228	89,230	298.7	-	0.2114	44,615	211.2	-	0.00614	0.00789	17.0	8.0	0.1353	28,550	169.9
-	0.4674	137,000	370.1	-	0.2337	68,500	261.8	-	0.00628	0.00803	17.5	7.5	0.1403	41,120	202.8
-	0.5765	191,400	437.5	-	0.2883	95,700	309.3	-	0.00635	0.00810	18.5	6.5	0.1499	49,750	223.1
-	0.5873	242,500	492.2	-	0.2937	121,250	348.2	"	0.00697	0.00872	18.0	7.0	0.1560	67,880	260.5
-	0.5627	223,100	472.4	-	0.2814	111,550	333.9	-	0.00721	0.00876	18.0	7.0	0.1575	62,440	249.8
-	0.8428	554,100	744.4	-	0.4214	277,050	526.3	-	0.00803	0.00978	19.4	5.6	0.1888	124,100	352.3
-	0.2748	11,510	107.3	-	0.1374	5,755	75.9	-	0.00355	0.00530	16.9	8.1	0.0890	3,729	61.1
-	0.3247	21,620	147.1	-	0.1624	10,810	104.0	-	0.00391	0.00566	17.4	7.6	0.09876	6.574	81.1
-	0.3898	41,280	203.2	-	0.1949	21,640	147.1	-	0.00446	0.00621	17.9	7.1	0.11070	11,725	108.3
-	0.3353	45,970	221.3	-	0.1677	24,985	158.1	-	0.00520	0.00695	16.5	8.5	0.1140	16,650	129.0
-	0.4196	65,620	256.2	-	0.2098	32,810	181.2	-	0.00513	0.00688	17.7	7.3	0.1225	19,160	138.4
-	0.4228	89,240	298.7	-	0.2114	44,620	211.2	-	0.00553	0.00728	17.5	7.5	0.1269	26,780	163.6
-	0.1777	1,160	34.1	"	0.08885	580	24.1	-	0.00283	0.00458	15.2	9.8	0.06966	456	21.4
-	0.2413	2,509	50.1	-	0.1207	1,255	35.4	-	0.00286	0.00461	16.9	8.1	0.07816	813	28.5
-	0.2061	3,413	58.4	"	0.1031	1,707	41.3	-	0.00314	0.00489	15.7	9.3	0.07666	1,270	35.6
-	0.2480	6,533	80.8	-	0.1240	3,267	57.2	-	0.00331	0.00506	16.5	8.5	0.08434	2,222	47.1
-	0.2889	458,100	676.8	"	0.1445	229,050	478.6	"	0.02127	0.02402	v = 21.51, V = 25.0	12.25	0.1472	233,500	483.3

The #6 BS. sample tested rose to 25° temp: elevation @ 102 in water by table 147
103 - ground 104
54 - air 81.

The #12 BS. . . . . 62 - water 58.4
55 - ground 41.3
35 - air 35.6

The 80,000 c.mil . . . . 325 - water 298.7
265 - ground 211.2
185 - air 170.0

The 200,000 . . . . 600? - water 641.4
455 - ground 453.5
315 - air 298.

If ρ = the thermal resistivity of the insulator
d & D = - int: and ext: diameters of successive coats
θ = - temp: elevation between conductor and sheath
r = - ohmic res of the cable per cm
ε = - total emissivity of the ext: surface per cm per °C
θ_1 = - the temp: of the ext: surface.

$$c^2 r = \frac{2\pi\theta}{\rho}\left(\log_e \frac{D}{d} + \log_e \frac{D_1}{d_1} + \quad\right)$$

$$\varepsilon = (\pi D \times 0.00111 + 0.00175)$$

$$\theta_1 \varepsilon = \frac{2\pi(\theta - \theta_1)}{\rho}\left(\Sigma \log_e \frac{D}{d}\right)$$

	C.L. Water	C.L. Soil	C.L. Air	C.L.A. Water	C.L.A. Soil	C.L.A. Air	C.L.A.W. Water	C.L.A.W. Soil	C.L.A.W. Air	C.L.A.I. Water	C.L.A.I. Soil	C.L.A.I. Air	C.L.A.J.W. Water	C.L.A.J.W. Soil	C.L.A.J.W. Air
[illegible],000	1580	1129	830	1280	910	800				1160	820	800			
[illegible],000	1630	1150	710	1140	810	700				1070	760	700			
600,000	~~1060~~	750	~~540~~							860 / 680	600 / 420	590 / 480	820	580	620
500,000	1060	750	510	770	550	480				760	540	510	690	490	530
[illegible],000	1010	710	490	860	610	450				680	480	520	630	450	490
[illegible],000	900	640	450	670	470	410				630	440	440	600	430	480
250,000	740	530	350	540	380	340				520	370	350	460	330	360
[illegible],000	640	450	300	460	320	290				440	310	300	380	270	300
[illegible],000	490	350	260	420	300	260				370	260	260	370	260	280
[illegible],000	470	330	250	390	280	250				360	260	250	320	230	260
[illegible],000	440	310	220	340	240	220				330	230	230	300	210	240
[illegible],000	370	260	200	290	210	200				280 / 300	200 / 220	200 / 160	280	200	220
[illegible],000	300	210	170	270	190	170				~~300~~ 260	~~220~~ 180	~~160~~ 180	230	160	180
[illegible],000	300 / 260	210 / 180	170 / 140							180	120	120			
[illegible],000	220	160	140							180	130	130	180	120	140
4	200	150	110	150	110	105	160	115	115						
6	150	100	80	120	80	80	120	83	85						
8	110	76	61	87	62	61	90	63	65						
10	81	57	47	65	46	47	70	49	51						
12	58	41	36	52	37	37	49	35	37						
14	50	35	29	40	28	29	38	27	32						
16	34	24	21	29	21	22	27	19	21						
	22			19 19			7			16			12		

Test of Storage Cells by Bonet.

These cells, already described, and whose tests are already recorded, were connected to a Walker photographic meter.

12th Sept.	Charge started				
13th "	" stopped	The reflex in large meter = 0·0850 and 0·0815. Mean 0·0833 =			
13th "	Discharge started.				
19th "	1st Discharge photographed		0·0705	0·0655	- 0·0680 =
21st "	2nd charge		0·137	0·1245	- 0·1308 =
8th Oct.	3rd "		0·042	0·041	- 0·0415 =
9th "	3rd discharge		0·04495	0·0550	- 0·0523
13th "	4th charge		0·07445	0·0805	- 0·07765
15th "	4th discharge		0·055	0·063	- 0·059
18th "	5th charge		0·106	0·103	0·10445 @ 10 amp

Test of the Heating of the large Magnet represented on page 116.

27th October. Resistance 7·954 ω @ 24·6°c.

Passed a current of 5 amperes through the magnet coils, from 14·0 to 23·15 o'clock. At 22·30, the current was 5·259 amperes. Also, the P.D. on magnet was 48·87 volts = 9·292 ω and 257 watts.

By bridge, the resistance was = 9·266 ω.

The temp. of the air was 18·0°c. and the observed temperatures on the magnet were :— 65·2°c on wire
63·6° " " "
54·0° " " iron face.

The mean temp. of the surface may be taken as 64°c., an elevation of 49°c.

The surface of the magnet amount is 2750 sq. cm approximately.

" " " " copper shaft		2800
	Total	5250
Energy per sq. cm.	0·04895	
Sq. cms. per watt	20·43	

No. of Sample	Composition	Diam.	Length	Elong. for 1 gram	Set	Actual composition of metal	
1	Copper with 7.4% tin	0.0350	7.0	1.5	0 after 1 gram	10 gram Cu + 0.7 gram Sn	
2	" " 4.75% "	"	"	1.5	" " "	10 Cu + 0.5 . Sn	
3	Silver . 5.66% copper	"	"	2.5	0.25 . 2.0	5 . Ag + 0.3 . Cu	
4	" . 16.67% " very little	"	"	2.2	0 . .	5 . . + 1.0 . . Cu	
5	" . 13.04% of Tin very little	"	"	2.0	0 . 3.3	20 . . + 1.0 . . Sn	
6	Aluminium . 3% Kirkburg	"	"	3.0	0 . 1.0		
7	" . 1% Copper very little	"	"	2.9	0 . 1.0		
8	" . 3% " very little	"	"	2.45	0.2 . 1.0		
9	Phosphor-bronze from store room	"	"	1.5	0 . 3.0		
10	White metal tube main spring		36.0	"	"	"	
11	Platinum platinum " "						
12	Delpine Lutz steel " "						
13	" " " " "						
14	Aluminium bronze wire	0.035	7.0	1.6	0.05 after 3.0		
15	Silver wire from a U.S. 10 d piece	"	"	1.75	0 . .		

Measurements of the Elasticity and Resistance of wires of various alloys.

136

All the wires were drawn to the diameter of 0.0335 cm, and 7 cms were mounted horizontally, held at one extremity in a brass clamp. The vertical displacement of the free end due to load applied at the 7th centimetre was observed.

Length cm	Diam. cm	Weight grm	Res. Ω	Res. per cm Ω	Cross section sq. cm	Resistivity (20 deg. C)	Sp. g.	Sp. g. from chemical volume	Wt in water	Sp. g. by water	Vol. by water
			17°C								
38.8	0.018	0.0660	1.320 Ω	0.034021	0.0002543	8.643×10^{-6}	6.52	0.0132	0.0768	9.348	0.092
77.4	0.018	0.1730	1.775 Ω	0.02293	"	5.836 "	8.78	0.0197	0.1565	9.538	0.0165
60.5	0.019	0.1575	0.540 Ω	0.008925	"	2.271 "	10.23	0.0154	0.1450	12.60	0.0125
90.7	0.018	0.2325	0.928 Ω	0.01010	"	2.358 "	10.05	0.02309	0.2210		0.0115
39.5	0.023	0.4235	1.770 Ω	0.014651	0.0004155	1.82×10^{-6}	8.75	0.01641			
32	0.020	0.0235	0.460	0.01437	0.0003146	4.515×10^{-6}	2.84	0.01005			
14.5	0.018	(	0.236	0.01627	0.0002543	4.161×10^{-6}					
100.5	0.018	0.223	4.725 Ω	0.04702	0.0002543	1.96×10^{-6}	5.72	0.02587			
36.0	0.0195 × 0.027	0.075	2.070 Ω	0.05750	0.0002243	1.397×10^{-6}	3.57	0.0087148			
25.5	0.0195 × 0.021	0.047	5.15 Ω	0.03197	0.000164	5.370×10^{-6}	10.97	0.006233			
26.1	0.021 × 0.019	0.048	8.25 Ω	0.320	0.000165	5.375×10^{-6}	10.95	0.006385			
34.4	0.0225 × 0.019	0.065	10.42 Ω	0.3029	0.000181.5	5.59×10^{-6}	10.24	0.006347			
94.8	0.020	0.2565	3.946 Ω	0.04162	0.0003146	1.303×10^{-5}	8.62	0.02979			
57.8	0.020	0.0	0.458 Ω	0.007922	"	2.489×10^{-6}					

Test of Standard Clark Cells

belonging to the Lamp Room. 10th October 92.

On A + B diff. galvo. one coil 2700 Ω approx. 1 B.c. to 18.2°C. 1.431 volt = 175 d. with 100,000 Ω in cct: Total res: 103,000 Ω cir. = 1.39×10^{-8} γ ∴ 1° = 7.94×10^{-8}

There is total res of 3000 Ω cir: one of these cells gave no discernible deflection in any pair back to back. With one #1 as standard, then #3 gave 5 div excess

#2 - 12 - defect

#4 - 1 - -

1 div. represents 23.82×10^{-5} volt = 2.382×10^{-4} volt: ∴ then #3 is in excess 1.19×10^{-3} volt

#2 - - defect 3.335×10^{-3} -

#4 - - - 2.382×10^{-4} -

The resistance of then 3 + 2 = 600 Ω approx

1 + 3 = 550 Ω -

2 + 4 = 450 Ω -

1600

800

#3 = 350 Ω -

2 = 250 Ω -

1 = 200 Ω -

$y = A\log x + B$

$1 = A\log 1.226$

$A = \frac{1}{0.08859} = 11.29$

$B = 0.04 + 11.29\log 64$

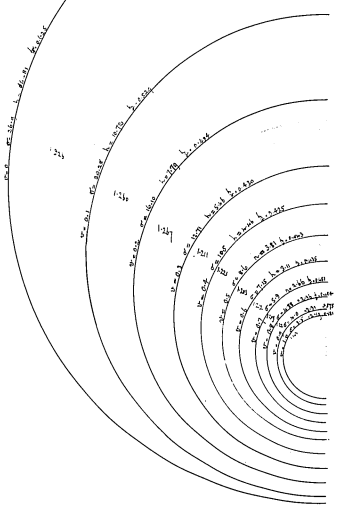
$= 0.04 + 11.29 \times 1.806$

$v = A$

$\therefore v = -11.29\log r + 8.716$

$\log r = \frac{8.716 - v}{11.29}$

Mean ratio 1.226

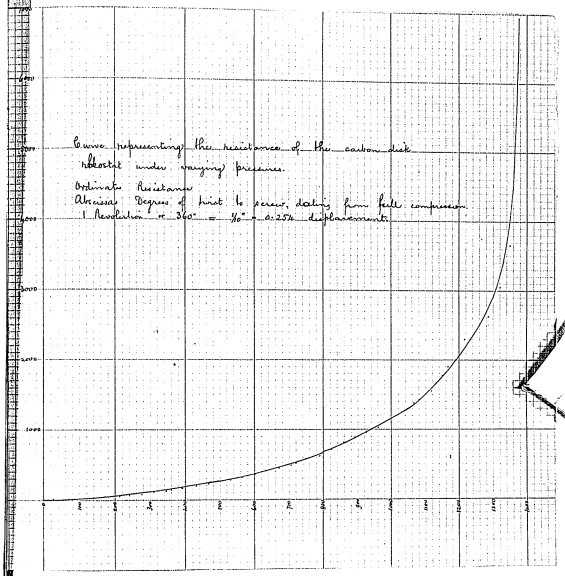


Measurements in connection with the problem of concentric cylinders.

Pot.	σ	ratio	v	h	$\frac{h}{d}$	v		$\frac{v}{\sqrt{1.29}}$	$1.557 - \frac{v}{\sqrt{1.29}}$	σ
0	26.9	1.326	+ 0.100	16.81	0.625	+ 0.125		0	1.557	
0.1	20.28	1.260	+ 0.034	10.72	0.529	+ 0.029		0.08858	1.46634	
0.2	16.10	1.247	+ 0.041	7.79	0.484	− 0.016		0.1771	1.4653	
0.3	12.71	1.211	− 0.015	5.44	0.430	− 0.070		0.2658	1.4896	
0.4	10.5	1.221	− 0.005	4.46	0.425	− 0.075		0.3542	1.4116	
0.5	8.6	1.203	− 0.023	3.81	0.443	− 0.057		0.4429	0.9357	
0.6	7.15	1.212	− 0.014	3.11	0.435	− 0.065		0.5315	0.8979	
0.7	5.9	1.209	− 0.017	2.66	0.451	− 0.049		0.6200	0.781	
0.8	4.88	1.220	− 0.006	2.36	0.430	− 0.020		0.7088	0.704	
0.9	4.0	1.143	− 0.083	2.31	0.576	+ 0.076		0.7972	0.6174	
1.0	3.5			2.19	0.621	+ 0.121		0.8858	0.551	3.557
		Mean 1.226			5.531 / 10					

A cylinder of nickled brass 30 cms in diam: was filled with distilled water to a depth of 2.6 cms A zinc cylinder 0.953 cms in diam: was immersed vertically in this at various points and observations made with a 16,000ω Weston voltmeter in circuit as follows:—

Dist. of surface of the metal edge	Dist. of nickled from edge	x	β	β^2	$\sqrt{1-\beta^2}$	V	v	$V_{v=0}$	$\frac{V_{v=0}}{V}$	ratio
–	15.0	0			1.	123.5	66.1	55.4	0.938	1.00
10.5	4.02	0.131	0.277	0.0767	0.961	124.0	67.0	55.0	0.821	0.880
8.1	6.4	0.22	0.441	0.1945	0.898	124.1	68.0	54.1	0.796	0.850
6.0	8.5	0.29	0.586	0.3431	0.810	124.1	69.5	52.6	0.757	0.803
4.45	10.05	0.35	0.693	0.4802	0.721	124.8	72.0	50.4	0.696	0.820
3.72	11.8	0.41	0.814	0.6626	0.581	123.8	75.5	46.0	0.607	0.724
1.25	13.27	0.46	0.915	0.8372	0.403	123.5	83.5	38.0	0.455	0.543


Curve representing the resistance of the carbon disk
rheostat under varying pressure.
Ordinate Resistance
Abscissa Degrees of twist to screw, starting from full compression.
1 Revolution = 360° = 1/10" = 0.254 displacement.
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Test of a Carbon adjustable resistance Oct. 18th

The essential parts of this instrument consist of a hard rubber vertical cylinder (1.85 inch diam.). At the base of this is a platinum faced brass electrode 1.75 in diam. At the top is a similar electrode at the end of a screw with 10 threads to the inch, let through the top of the instrument so as to vary at will the distance between the lower fixed and upper movable horizontal electrodes. Between them are compressed the disks of carbonized paper 0.020" thick and 1.75" in diam. The extreme distance between the disks is 2.99 ; adjustable by a milled washer on the screw to 1.47". The resistance between the electrodes was measured at various distances apart, as follows:—

Angle		Res:	No. of Obs.	Angle		Res	No. of Obs.	Angle		Res:	No. of Obs.	Angle		Res
0		2.8	12	105	360°	135	23	210	720°	510	34	315	1080	1420
10	34.3°	5.0	13	115	394.3	162	24	220	752.4	580	35	325	1115	1550
20	68.6	9.0	14	125	428.6	195	25	230	788.7	620	36	335	1149	1760
30	102.9°	15.0	15	135	462.9	227	26	240	822.9	710	37	345	1183	1900
40	137.2	25	16	145	497.2	257	27	250	857.2	810	38	355	1217	2030
50	171.5	37	17	155	531.5	285	28	260	891.6	890	39	365	1252	2300
60	205.8	52	18	165	565.8	320	29	270	925.8	955	40	375	1286	2620
70	240.0	67	19	175	600.	360	30	280	960.0	1030	41	385	1320	3050
80	274.3	85	20	185	634.3	405	31	290	994.3	1150	42	395	1354	3650
90	308.7	105	21	195	668.6	440	32	300	1029.	1250	43	401	1375	7150
100	343.	127	22	205	703.	495	33	310	1063.	1380	44	402	1378	7700

Test of a phonoplex Receiving Coil 14th Oct: 92.

Res: @ 18°C. 97.9Ω two coils in series.

Wire #35 B.W.G. or #36 B.S. 0.005" d.c. c. to 0.010".

Bay 100Ω @ 20°C. = 0.2934 gr. or 0.1467 gr. on each spool.
= 0.01834 lbs. or 0.00917 lb. on each spool
~~2622~~ feet = 1211.1 feet

Length of mean turn 2" approx.

Total turns 1453 . 727 turns

Tests of Disc Ammeter Models 2 & 3.

15th Oct. 92.

Winding on one disk 100 turns of #37 B.S. 0.00445" d.i.c. & 0.00
Resistance 18.5ω Weight 8.17 gms. counterpoised without spring.
Weight unwound 4.75 gms weight wound 7.47. Wire 2.72 gms.
During counterpoised disk from a vertical suspending wire. Period = 5.1143 secs
loaded - - with a cylinder of fibrous - 18.25 -
Mass of fibrous cylinder. 34.155 gms. Wire #35 B.S. 0.0055" d.i.c. & 0.0094".
Int: rad - - 1.8125 cms
Ext - 4.10 -
Moment of Inertia 3443 cm² gms.
Moment of Inertia of disk 29.625 cm² gms
Radius of gyration 1.9 cms.

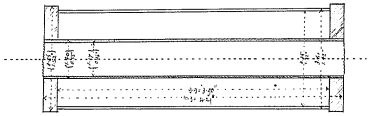
Ammeter armature 50 turns 1.64ω 11.02 gms. without counterpoise.
Weight of wire 6.25 -
Weight - counterpoise 1.325 -
Total weight of disk 12.3275 - counterpoised.
Period of counterpoised but unloaded disk 6.704 secs
- - and loaded - 19.16
Moment of inertia of counterpoised disk 47.85 cm² gms
Radius of gyration 1.97 cms.
Diameter of wire 0.0124" d.i.c. & 0.0150" # 28 B.S.

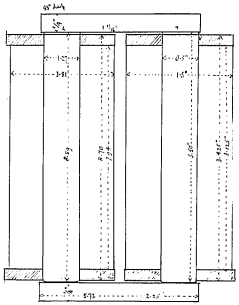
With drum silver springs each about 27 cms. long 0.005" × 0.023" (0.0127 × 0.058)
The resistance of the ammeter = 1.873 = @ 19°.C. taming 0.23 ω in springs
Pull of 0.285 gms. @ rad: of 1.65 cms = 0.470 cm. gms. for 61.25° or nearly
half load. = 0.007678 cm. gms per° = 0.96 cm. gms. at full load.

The following observations were made with the completed instrument on the 25th Oct.

No. of Obs	P.D. across 20.146ω	Amp:	Deflection of instrument	Deflection per amp:	gms / 3	5	9	gms / gms
1	0.1185	0.005492	9°	1639				
2	0.255	0.01268	20°	1577				
3	0.3805	0.01592	30°	1586				
4	0.5085	0.02525	40°	1584				
5	0.6270	0.03117	49.35°	1583				
6	0.7675	0.03816	61°	1599				
7	0.892	0.044434	70°	1579				
8	1.031	0.05126	80.5°	1571				
9	1.168	0.05806	90°	1550	2.083	1.183	1.873	0.725ω
10	1.315	0.06537	100°	1530				
11	1.450	0.07208	108.25	1502				
12			122°					

The weight of a 1 3/16 × 1/2" magnet is 2lbs 6 1/2 oz. = 38.5 oz.
3/16 - -
22.9 -
Diff 9.6 oz = 0.6 lb = @ 0.34 lb-ft





Analysis and Data of Phonoplex apparatus. Oct. 19th

No. 1. Coil.

Diameter of wire	=	#23 B&S 0.0225" cotton cond. to 0.0285"
Resistance	=	7.15 ω @ 20°C.
Inductance	=	132 millihenrys.
Time Constant	=	0.01846 sec.
Mean diameter of wire	=	1"
" circ.	=	3.14116" = 0.2618'
Number of turns per layer	=	128
Number of layers.	=	13.
Total length of wire	=	433'
" weight	=	0.519 lb.
" number of turns	=	1650
Core left main wire	=	0.0328" #20 B&S.
Weight of core	=	45.5 g. 0.100 lb.
Number of wires	=	111.
Length each wire	=	4.3" = 11 cm.
Total length of iron wire	=	39.8'

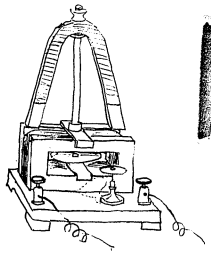
Diameter of wire	=	0.0128" d.c.c. to 0.0172" #28 B&S.
Resistance	=	75ω on each spool, or 150ω in all.
Mean winding diam.	=	1"
Mean circ.	=	3.14" = 0.2619'
Total no. of turns per layer	=	190
" length of wire	=	1153' on each spool 2306' in all.
" weight	=	0.555 lb. " " 1.110 lb. " "
" number turns	=	4404 " " 8808 " "
" " of layers	=	26. " " "
" weight	=	1142 gms.

26 × 0.0172 = 0.45

Resistance box of 5 coils

Diameter of wire	=	0.0159" d.c.c. to 0.0205" #26 B&S.
Interflange	=	0.84"
Length of spool	=	1.0"
Diameter over winding	=	0.66"
Base diameter	=	0.375"
Turns per layer	=	37
Flange diam.	=	0.75"
Number of layers	=	8.
Total number of turns	=	296
Total resistance	=	10.2ω @ 20°C. or 2.04ω per spool.
Length on each spool	=	50' or 250' in all.
Weight " " "	=	0.0383 lbs. or 0.1915 lbs in all.

Base of walnut wood = 6" × 3¾" Cover 1.425" high × 1.5" × 5.325".



Measurement of the elastic constants of springs in wire from made from various alloys

(Wel)

A length of 400 cms. mounted in the magnetometer with one of the vibrators gave

7 swings in 62 secs			=	8·857 secs per ~
34	-	300	=	8·8235
192	-	1765	=	8·8229
151	-	1331	=	8·8146
269	-	2373	=	8·8216

The same vibrator loaded with a ring whose dimensions are

$R = 5{\cdot}964 \div 2 = 2{\cdot}982$

$r = 3{\cdot}993 \div 2 = 1{\cdot}9965$

$M = 167{\cdot}2$ gms.

$I = \frac{M}{2}(R^2 + r^2) = 83{\cdot}645\,(8{\cdot}8922 + 3{\cdot}986) = 83{\cdot}6445 \times 12{\cdot}8793 = 1078{\cdot}9$ cm²gms

7 swings in 128 secs			=	18·287 secs. per ~
37	-	677	=	18·2162
64	-	1171·5	=	18·3046

Moment of inertia of unloaded vibrator $= \frac{8{\cdot}8216^2}{18{\cdot}3046^2 - 8{\cdot}8216^2} \times 1078{\cdot}9$

$= \frac{77{\cdot}82}{335{\cdot}06 - 77{\cdot}82} = \frac{77{\cdot}82}{258{\cdot}24}$

$= 325{\cdot}36$ cm²gms.

The torsional moment of the wire $= \frac{4\pi^2 I l}{T^2 n} = \frac{4 \times 9{\cdot}869 \times 325{\cdot}36 \times 400}{77{\cdot}82} = 6602$

The wire was drawn through a sapphire draw-plate 0·020 cm.

With a wire drawn through the same die, from dense silver, the length 39 cms, there were 5 swings in 163 secs = 32·6 secs per ~ with loaded vibrator

9	-	293	=	32·55
26	-	849	=	32·654

$I = 11004{\cdot}26$ cm²gms

$\mu = 39{\cdot}4784 \times 11004{\cdot}3 \times 39 / 1066{\cdot}3 = 2027{\cdot}5$

Dimensions of a galvanic tourniquet for the Motor Point Area

Internal length of coil = 3·0"
- breadth - = 1·2"

Interflange = 1·0" 2·54

Filled with #31 B.H. 0·0089" s.c.c.

The finished dimensions are

Mass of disk = 4·175 gms including agate cap

Diameter . . = 6·35

Thickness . . = ·01524 (0·006")

No. of turns in coil = 2180

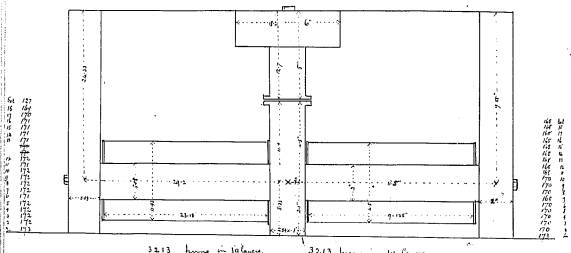
Resistance of coil = 220 ω @ 19°C.

Inductance . . = 0·335 H with disk in place.

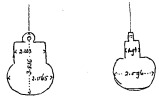
After having been brought, by an small medical induction coil, with 2 cells spinning it to a speed of 160 rpm. the magnet was suddenly removed and the secondary circuit broken. The disk took 320 seconds to stop rotating and break into oscillations. Without magnetisation it might have required 8 mins. to come to rest.

The instrument does not rotate when operated by an alternating current transformer.

Magnetic Bridge Elevation 1/4



Mass of disk and pointer 28 g.



Magnetic Bridge for Testing Samples of Iron and Steel.

Core diameter = 5·08

Cross section in core = 20·3 sq. cms.

Upright = 5·08 × 5·08 (2" × 2")

" Cross section = 23·18

Winding depth = 2·54 (1")

Interlining = 23·18.

Tot. wire surface on each spool = 739·4 sq. cms.

Winding = 19 layers of 170 turns = 3230 turns on each spool of #19 B.W.G. 0·042" s.c.c. to 0·053".

Diameter of mean turn = 12·4·0"

Circumference = 12·57" = 1·05'

Total length of wire = 339·2' on each spool. (678·4' in all)

" weight = 18·13 lbs (36·26 lbs)

" resistance = 19·84 ohm @ 20°C = 22·7 = @ 60°C. (39·6 = 0·0055)

Current through coil only @ 120 = 3·03 amp.

Excitation = 20,555 ampere turns. = 258·40 abs. or 2584 gilb.

Energy developed at 120 volts = 364 watts or 4·06 sq. cms. per watt.

Bridge area Diameter = 7/8 and 1·55

Area = 2·93 − 0·93 = 2 sq. cms.

Air gap = 1/16" 0·16 cms.

Reluctance of gap = 8·26 millimegalds = 0·00836.

Disk diameter = 2" 5·08

Winding = 100 turns of #22 B.W.G. 0·014" d.s.c. to 0·017".

Particulars of a glass vibrator 27th Oct. 92.

A glass clapper was made having the spherical portion about in diameter, surmounted by a flat square portion, and this again by a glass eye. The weight in air of this clapper was 16·4025 gms. after a little square plate of thin microscope glass had been scarred on one of its flat surfaces by canada balsam. The weight in tap water @ 20° C. was 9·132 gm.

volume 7·271 c.c.

Sp. gr. 2·256

This was suspended by a platinoid wire, and observed to make 200 period in 481 secs. or 2·405 secs per ~.

The standard vibrator was mounted on the same wire and observed to make 71 swings in 1190 secs or to have a period of 16·761 secs.

$$T_1 = 1/(16.761)^2 \times (2.405)^2 \times 325.36.$$

$$\frac{5.7844}{280.9976} \times 325.36$$

$$= 6.70 \text{ cm gms.}$$

This clapper was suspended by a ~~small~~ composite silk fibre in a vertical glass tube 2·5 int. diam. The length of the fibre was 22 and its diameter 0·005 (hanging freely) in this tube which was carefully exhausted, the periodic time was about 60 seconds. When the pointed poles of the large electromagnet were brought up to the opposite sides of the glass tube, without touching it, & the magnet excited, the periodic time reduced to 18 seconds.

Determination of the best winding for a disk ammeter.

Let l = the length of one turn on the disk
n = " number of turns.
α = " mean effective magnetic action radius
σ = " specific gravity of the wire
ρ = " resistivity " " " " Abs. measure
d = " diameter " " " cm.
m = " mass " " " gms.
r = " resistance " " " " abs. meas.
s = " " of each spring " " "
μ = " moment of magnetic force (cm. dynes)
γ = " current in the disk. abs. meas.
e = " emf impressed upon the disk . . .

$$t = \frac{4 l \rho n}{\pi d^2}$$

$$R = 2s + \frac{4 l \rho n}{\pi d^2} = \frac{2 s \pi d^2 + 4 l n \rho}{\pi d^2}$$

$$\gamma = e/R = \frac{e \pi d^2}{2 s \pi d^2 + 4 l n \rho}$$

$$\mu = \gamma H \frac{n}{3} \alpha = \frac{\alpha H e n \pi d^2}{6 s \pi d^2 + 12 l n \rho}$$

$$m = \frac{l n \pi d^2 \sigma}{4} \quad \therefore d^2 = \frac{4m}{l n \pi \sigma}$$

$$\therefore \mu = \frac{4 \alpha H e n \pi m}{6 s \pi \cdot 4m + 12 l^2 n^2 \pi \rho \sigma} = \frac{\alpha H e n m}{6 s m + 3 l^2 n^2 \rho \sigma} = \frac{\alpha e m H}{3} \Big/ \left(\frac{2sm}{n} + l^2 n \rho \sigma\right)$$

$$\frac{d\mu}{dn} = \frac{\alpha e m H}{3} \left(\frac{l^2 n^2 \rho \sigma + 2ms - 2n^2 l^2 \rho \sigma}{(2sm + l^2 n^2 \rho \sigma)^2} \right)$$

For a maximum $l^2 n^2 \rho \sigma = 2ms$

or $n = \frac{1}{l} \sqrt{\frac{2ms}{\rho \sigma}}$

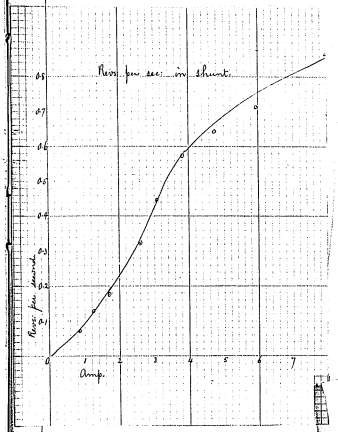
For the best shine silver springs $2s = 0.23 \times 10^7$ $m = 6.3$
$\rho = 1700$ $\sigma = 8.9$ $l = 15$

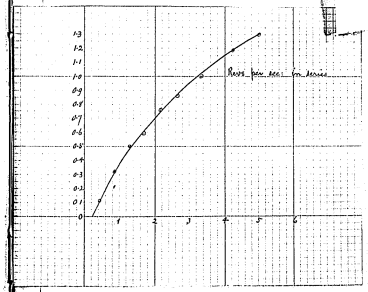
$$n = \frac{1}{15} \sqrt{\frac{1.45 \times 10^7}{1.573 \times 10^7}} = \frac{100}{15} \sqrt{9.25}$$

$$= \frac{307}{15} = 21 \text{ wires.}$$

Proposed standard ratings of ammeters

0 to 0.050
0 to 0.250
0 to 0.500
0 to 1
0 to 2.5
0 to 5.0
0 to 10.0 above to 0 – 15


Revs per sec. in shunt.
Revs per second
Amp.
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
1
2
3
4
5
6
7


Revs per sec. in series
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1
2
3
4
5
6

Tests of Patent-Motor-Meter whose design appears on page 132.

31st Oct. 92.

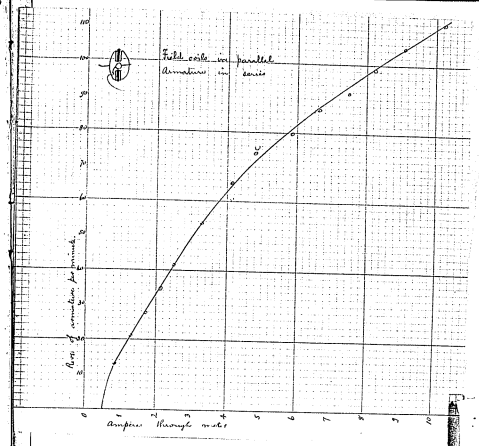
Machine just completed, oiled, and connected as a shunt motor

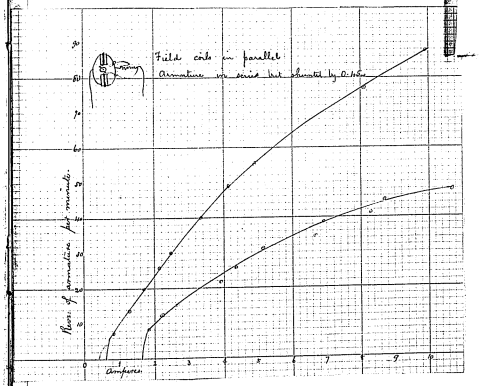
No. of Obs.	Time	Elapsed	Revs. of armature	Secs. per rev.	Revs. per sec. of armt.	Lamps	Obsd.	Amp.	Revs. per sec. per amp.
1	14·58·13 / 59·27	69	5	13·8	0·07246 / 46876	2	0·168	0·8668	0·08364
2	54·13 / 55·31·5	78·5	10	7·85	0·12739 / 5240	3	0·241	1·2414	0·1024
3	56·46 / 58·38	112	20	5·60	0·1786 / 3916	4	0·331	1·708	0·1046
4	59·31 / 10·7·30	92	20	3·06	0·3268 / 18588	6	0·57	2·632	0·1242
5	1·22 / 2·30·5	67·5	30	2·25	0·4444 / 28514	8	0·596	3·076	0·1443
6	3·27 / 5·14	87	50	1·74	0·5747 / 36682	10	0·74	3·818	0·1506
7	6·15 / 7·36	78	50	1·56	0·6410 / 3846	12	0·915	4·722	0·1357
8	8·53 / 10·35	70	50	1·40	0·7143 / 42858	15	1·158	5·975	0·1195
9	10·59·5 / 11·57	57·5	50	1·15	0·8696 / 52176	20	1·56	8·05	0·1080
10	13·05 / 14·10	65	5	13·0	0·07692 / 46152	2	0·178	0·892	0·0836

No. of Obs.	Time elapsed	Elapsed	Revs. of armt.	Secs. per rev.	Revs. per sec. of armt.	Lamps	Obsd.	Amp.	Revs. per sec. per amp.
1	18·52 / 4·23	92	10	9·2	0·1086	1	0·088	0·4654	0·2342
2	20·12 / 1·15	63	20	3·15	0·3175	2	0·170	0·877	0·3621
3	22·26 / 23·06	40	20	2·0	0·500	3	0·259	1·336	0·3743
4	·38 / ·55	17	10	1·7	0·5882	4	0·332	1·713	0·3433
5	25·03 / 26·41 / 27·28 / ·86	66	50	1·32	0·7576	5	0·422	2·178	0·3478
6	·25 / ·43	58	50	1·16	0·8621	6	0·5703	2·633	0·3275
7	·25 / ·38	58·5	50	0·99	0·1010	8	0·650	3·354	0·3011
8	·30 / ·50	95	100	0·95	0·1176	10	0·820	4·232	0·2779
9	·55 / ·21	86	100	0·86	0·1162	10	0·820	4·232	0·2745
10	·35 / 29·5	77	100	0·77	1·299	12	0·97	5·005	0·2595
11									
12	·	88	10	8·80	0·136	1	0·085	0·438	
13									

Res. of armature, brushes, + cond. 0·210 ω @ 15°C.
" " Field coils Right Hand 0·186ω
Left " 0·143ω

Frictions. Armature only 2·40 revs. per
Brushes on 10·90 " "
Counter + " 12·0 " "
Fan " " 30·0 " "


Field coils in parallel
Armature in series
Revs. of armature per minute
Amperes through motor


Field coils in parallel
Armature in series but shunted by 0.1 Ω
Revs. of armature per minute
Amperes

Test of Motor Meter contd.

The two field coils in parallel and the armature then in series.

No. of Obs.	Time	Interval	Revs. of arm.	Secs. per rev. of arm.	Revs. of arm. per sec.	Revs. of arm. per min.	Revs. of fan per min.	Lamps	Ohmch.	Amp.	Revs. per amp.
1	8.12.03 / 24.5	4.55	10	4.55	0.2198	13.188	131.9	2	0.166	0.1586	1.8014
2	12.40 / 14.37	57	20	2.85	0.3509	21.054	210.5	3	0.252	1.30	16.19
3	15.15 / 15.27	54	25	2.16	0.4630	27.78	277.8	4	0.330	1.703	16.31
4	16.355 / 17.18	52.5	30	1.75	0.5714	34.264	342.6	5	0.412	2.126	16.12
5	18.04 / 19.02	58	40	1.45	0.6897	41.382	413.8	6	0.492	2.529	16.3
6	19.405 / 20.34.5	56	50	1.12	0.8929	53.574	535.7	8	0.642	3.313	16.17
7	21.37 / 22.29	42	100	0.42	1.037	62.22	622.2	10	0.808	4.169	14.52
8	23.47 / 24.22.5	81.5	100	0.815	1.227	73.620	736.2	12	0.970	5.005	14.70
9	25.55 / 26.36	90	120	0.75	1.333	79.98	799.8	14	1.132	5.852	13.67
10	28.18 / 29.19.5	69	100	0.69	1.449	86.94	869.4	16	1.290	6.676	13.06
11	29.46 / 30.51.5	65.5	100	0.655	1.527	91.62	916.2	18	1.450	7.482	12.25
12	31.23 / 32.24	61	100	0.61	1.639	98.34	983.4	20	1.600	8.256	11.91
13	33.36 / 34.38.5	57.5	100	0.575	1.739	104.34	1043.4	22	1.770	9.132	11.42
14	36.27 / 37.44.5	55.5	100	0.555	1.869	112.14	1121.4	25	1.985	10.244	10.95

Two field coils in parallel, armature in series with a shunt across its terminals 0.445 ω in res.

No. of Obs.	Time	Interval	Revs. of arm.	Secs. per rev. of arm.	Revs. of arm. per sec.	Revs. of arm. per min.	Revs. of fan per min.	Lamps	Ohmch.	Amp.	Revs. per amp.
1	11.10.19 / 11.31	79	70	7.9	0.1269	7.614	76.14	2	0.162	0.836	9.104
2	12.38 / 13.24	46.25	10	4.625	0.2162	12.972	129.7	3	0.241	1.244	11.15
3	15.14 / 16	150	50	3.0	0.3333	20.	200	4	0.327	1.688	11.85
4	18.37 / 20.33	116	50	2.32	0.4310	25.86	258.6	5	0.413	2.131	12.14
5	21.38 / 23.18	100	50	2.00	0.500	30.	300	6	0.495	2.551	12.24
6	24.57 / 27.54	75	50	1.50	0.6667	40.	400	8	0.652	3.368	11.89
7	28.15 / 29.47	61.5	50	1.23	0.8130	48.78	487.8	10	0.803	4.144	11.77
8	30.52 / 32.44	108	100	1.08	0.9259	55.554	555.5	12	0.947	4.887	11.37
9	34.28 / 35.11	83	100	0.83	1.205	72.30	723.0	15	1.182	6.10	11.85
10	37.51 / 39.13	78	100	0.78	1.282	76.92	769.2	20	1.567	8.086	9.512
11	41.24 / 43.25	68.5	100	0.685	1.460	87.6	876.	25	1.920	9.908	8.842

Test of Motor Meter for Edison Patent Unit contd.

Field coils in parallel, and armature also.

Nov. 1st

No. of Obs.	Times	Interval	Revs. of armr.	Secs. per rev. of armr.	Revs. of armr. per sec.	Revs. of armr. per min.	Revs. of armr. per min.	Lamps	Shunt	Amp.	R. per min. per amp.
1	4.42.31 / 4.47.45.5	74.5	10	7.45	0.1342	8.052	80.52	4	0.345	1.78	4.52
2	4.49.31 / 4.50.50.5	49.5	10	4.95	0.2020	12.12	121.2	5	0.428	2.209	5.486
3	4.57.35 / 4.59.41	79	20	3.95	0.2545	15.27	152.7	7	0.516	2.663	5.7314
4	5.6.2 / 7	50.5	20	2.525	0.3960	23.76	237.6	9	0.755	3.896	5.556
5	5.13.19 / 5.13.37	58	25	2.32	0.4310	25.86	258.6	10	0.845	4.36	5.932
6	5.19.57.5 / 5.21.54.5	97	50	1.94	0.5155	30.93	309.3	12	0.995	5.135	6.022
7	5.28 / 5.34	85	50	1.70	0.5882	35.292	352.92	14	1.290	6.656	5.152
8	5.48 / 5.58	78	50	1.56	0.6410	38.46	384.6	16	1.340	6.912	5.564
9	5.59 / 6.12	73	50	1.46	0.6849	41.094	410.9	18	1.61	8.308	4.946
10	6.24 / 6.41	67	50	1.34	0.7463	44.778	447.8	20	1.69	8.72	5.135
11	6.52.7 / 7.5.2	63	50	1.26	0.7937	47.622	476.2	25	2.08	10.73	4.438

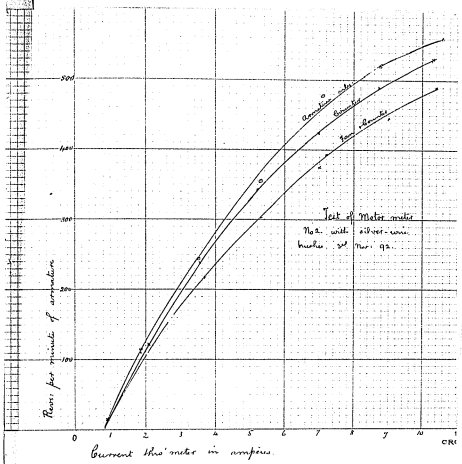
For the curve of these results see the lower chart of the preceding page.

Test of the preceding Motor & Meter w.c. for which see Book V. p.

Both field coils in series, and the armature in shunt.

	Times	Interval secs.	Revs. of armr.	Secs. per rev. of armr.	Revs. of armr. per sec.	Revs. of armr. per min.	Revs. of armr. per min.	Lamps	Shunt	Amp.	R. per min. per amp.
1	10.57.18 / 11.00.15.5	177.5	1375	0.	0.7746	46.476	465	24	1.95	10.06	46.2
2	11.1.38 / 11.3	193	1375		0.7126	42.762	427.5	22	1.805	9.312	45.9
3	5.29 / 8.83	209	1375		0.658	39.48	395	20	1.675	8.64	45.7
4	4.36 / 12.57	191	1100		0.576	34.56	345.5	18	1.495	7.71	44.8
5	12.31 / 1.18	214.5	1100		0.513	31.8	318	16	1.320	6.81	46.7
6	19.16.5 / 21.30	199	825		0.415	24.9	249	14	1.143	5.90	42.2
7	1.00	60"	210				210	12	1.000	5.37	39.1
8	1.00	-	167				167	10	0.833	4.30	38.8
9	-	-	123				123	8	0.655	3.38	36.4
10	-	-	83				83	6	0.51	2.63	31.5
11	-	-	63				63	4	0.42	2.17	29.0
12	-	-	31				31	2	0.335	1.73	17.9

50 teeth on worm wheel, 10 on pinion
85 - - intermediate - 10 - } 275 revs. of shaft to 1 unit on dial.
100 - - unit -


Test of Meter meter
No 2. with silver-wire.
Inertia. 30th Nov. 92.
Revs. for minute of armature
Current thro' meter in amperes
0
1
2
3
4
5
6
7
8
9
10
100
200
300
400
500

Test of Motor = Meter No. 2.

New silver wire brushes were ~~not~~ substituted and the following measurements made (1) with the fan spindle off, armature only running, counter indicating but fan off
(2) - - - -
(3) - fan and counter both at work.

No. of Obs.	Time	Revs.	R.p.m.	Obsrvd	Amps	Amp.	R. from fan Amp.		
1	one min.	114.2	114.2	0.180	2	4.0929			Armature only
2	"	116	116	0.365	4	1.8844			
3	"	244	244	0.680	8	3.5099			
4	"	355	355	1.030	12	5.315			
5	"	477	477	1.377	16	7.106			
6	"	520	520	1.700	20	8.772			
7	"	560	560	2.050	24	10.58			
8	"	155	155	0.182	2	0.939			Armature reversed
9	"	121	121	0.349	4	2.084			
10	"	239	239	0.685	8	3.535			
11	"	342	342	1.010	12	5.211			
12	"	374	374	1.360	16	7.018			
13	"	490	490	1.700	20	8.771			
14	"	530	530	2.000	24	10.32			
15	"	114.5	114.5	0.188	2	0.970			Armature, counter, & fan
16	"	110	110	0.360	4	1.858			
17	"	216	216	0.710	8	3.664			
18	"	302	302	1.030	12	5.315			
19	"	393	393	1.390	16	7.172			
20	"	445	445	1.740	20	8.980			
21	"	490	490	2.020	24	10.42			

Motor Meter #5 when running under test suddenly developed an irregular motion. The origin of this was finally traced to electrical trouble in the armature. A variable short = circuit was found to exist between the layers and the armature had eventually to be rewound.

$x = 42.35\,\varepsilon^{-0.000\,6315\,t} \sin \frac{t}{38.77}$

$x = 53.3\,\varepsilon^{-0.002\,7155\,t} \sin \frac{t}{31.2}$

log 42.35 = 1.626485
log 32.3 = 1.509230
0.117165

T. 0707119
0.3022157
T. 4325010
log 0.270090
log 42.4 = 2.6324573
Ar. 7003503

log 53.3 = 1.726713
log 20.7 = 1.315877
0.410836

T. 6128581
0.3622157
T. 9750738
log 31.3 = 2.4919555
5.433293 03 = 0.27155

Magnet unexcited

No. of Obs.	Time	Period	No. of Period	Deflection	Amplitude
1	17.04.05			26.7	
2		36		69.05	42.35
3	04.44	0.36	1	27.1	41.95
4		36		68.7	41.6
5	5.20	0.72	2	28.5	40.2
6		35		68.3	39.8
7	5.55	1.50	3	27.8	40.5
8		37		67.7	39.9
9	6.35	2.27	4	28.2	39.5
10		40		67.65	39.45
11	7.15	3.07	5	28.3	39.35
12		35		67.2	38.9
13	7.53	3.45	6	28.55	38.65
14		37		67.1	38.55
15	8.20	4.12	7	29.0	38.1
16		37		65.8	36.8
17	8.55	4.47	8	29.0	36.9
18		34		66.4	37.4
19	9.31	5.23	9	29.2	37.2
20		37		66.2	37.0
21	10.08	6.00	10	29.5	36.7
22		36		63.4	33.9
23	.43	6.35	11	29.8	33.6
24		36		63.1	33.3
25	14.19	7.11	12	30.1	33.0
26		36		62.7	32.6
27	.53	7.45	13	30.4	32.3
28				62.7	32.3
29		$\frac{465}{13}$ = 35.77 secs			
30					

Magnet excited

No. of Obs.	Time	Period	No. of Period	Deflection	Amplitude
1	17.18.38			21.8	
2		31		75.1	53.3
3	19.08	0.35	1	24.3	50.8
4		33		72.25	47.95
5	19.39	1.06	2	26.6	45.65
6		31		70.5	43.9
7	20.10	1.37	3	28.4	42.1
8		33		68.2	39.8
9	.42	2.09	4	30.0	38.2
10		31		66.5	36.5
11	21.13	2.40	5	31.5	35.0
12		31		64.95	33.45
13	.44	3.11	6	32.8	32.15
14		34		63.6	30.8
15	22.18	3.45	7	33.9	29.7
16		34		62.3	28.4
17	.48	4.15	8	35.1	27.2
18		34		61.25	26.15
19	23.19	4.46	9	36.9	25.35
20		31		62.2	26.3
21	.50	5.17	10	36.75	25.45
22		34		59.4	22.65
23	24.20	5.47	11	37.4	22.0
24		33		55.7	21.3
25	.53	6.20	12	38.0	20.7
26					
27					
28					
29		$\frac{394}{12}$ = 32.66			
30					

Vibration of Quartz Sphere in Magnetic Field.

A sphere of quartz from the Edison - Hardy collection has a mean diameter of 1.504" = 3.820 cms. The maximum diameter is equatorial being 1.514" = 3.845 " The minimum diameter is near the pole and 1.498" = 3.805 "

The weight of this sphere in air is 75.2925 gms

log 4.20 16C $\frac{46.916}{28.3765}$ sp. g. 2.6535

A hole has been bored in this sphere 0.25" (0.635) in diameter, and 1" (2.54) deep. The direction of this hole is not quite diametrical. The base of it is rough and unfinished.

A small cork was fitted into this hole, and the high silk thread taken from the centre of the cork, which is alluded to here as the pole. The length of the suspending composite fibre was 22.5. The fine silk fibre made one turn round the sphere on a longitude meridian, in order to render the vibrations visible. The sphere was freely suspended in air between the equator poles of the electromagnet, which were separated by 4.15 leaving 0.165 clearance on each side of the sphere. Glass plates set vertically against the poles, acted as windows, and tended to prevent disturbances from air currents. The sphere was set rotating about its suspension fibre with the magnet idle, and again with the magnet excited.

Magnet idle, 11 complete periods effected between 16.58.02 and 17.22.19 = 24.16
= 1456 seconds = 132.3 secs per n.

The amplitude diminished in 8 periods from 75° to 10°

When the magnet was excited, the sphere executed 7 complete periods between 17.23.58 and 17.29.48 = 590 seconds = 50 secs. per n and the amplitude diminished in the same time from 65° to 6° = 10.83

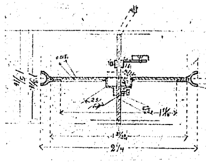
$\lambda_1 = \frac{2.3026}{16} \log 7.5 = \frac{2.3026}{16} \cdot 0.87506 = 0.12436 \quad \frac{\lambda_1}{T} = \frac{0.12436}{66.15} = 2.031 \times 10^{-3}$

$\lambda_2 = \frac{2.3026}{13} \log 10.83 = \frac{2.3026}{13} \cdot 1.03418 = 0.1833 \quad \frac{\lambda_2}{T} = \frac{0.1833}{25} = 7.33 \times 10^{-3}$

The measurement was repeated more carefully as follows, on the 8th Nov. A glass rod 19 long, and 0.294 in diameter, was fastened into the wall orifice with sealing wax, and at the upper end of the rod, a mirror was attached and a suspension wire of copper 32 long and 0.007 in diameter. The apparatus was shielded from air currents and observations of a scale made by telescope, the distance between mirror and scale being 1468 cm.

For the continuation of this series see p. 153.

The copper suspension was having given way, one of Pt. Ir alloy was substituted having a diameter of 0.0079 and a length of 35.



Finished dimensions 6¼" × 8¼" × 2·4" Weight 5 lb 2½ oz.

$$343 \times \frac{6.255^2}{18.4^2 - 6.255^2} = 343 \times \frac{39.125}{338.56 - 39.125} = 343 \times \frac{39.125}{299.435} = 44.82$$

$$\sqrt{\frac{44.82}{13.71}} = 3.269^{\frac{1}{2}} = 1.808$$

For 10 ampères the drop in the instrument between terminals was 0.175 volt
but between pressure wires 0.016ω = 0.16 volt.
Resistance of disk circuit = 1.075 ω.
Current in " " at load = ·1488 amp.
Arc traversed by pointer - - = 120° for 10 amp. or 12° per amp.
Current in disk cct: per degree = ·00124 amp. = 0.000124 = 1.24×10^{-4} abs.
" " each wire of disk per degree = 6.2×10^{-6} abs.
Number of turns of wire in field = 25·5 average. say 26.
Mean length of wire in each ..... = 2.0 cms.
Total " " active wire = 52 cms.
Mean radius of action = 1.53 "

$H \times 52 \times 1.53 \times 6.2 \times 10^{-5} = 9.064 \times 0.981$, H. = 1800. = 18 microgauss
Total useful flux = 18,000 = 180 ~~microwebers~~
Cross section of magnet = 2.86 × 1.05 = 3.0
Useful intensity in magnet = 6000 = 60 microgausses

Description of an ammeter made by the Chloride of Silver Battery Co: 7th Nov.

✓ This instrument consists of a rectangular coil of wire, with a pair of astatic rhombus steel needles, one within the coil, the other over it. The upper needle is supported on a jewel center, the lower is attached by a strap. A pointer is brought to a scale in front. The influence of external fields is limited by a small permanent horseshoe magnet at the base, with its poles nearly closed by a bar, capable of a limited degree of motion by a screw projecting through the case of the instrument. There are two shunts one ⅕th the other 1/50th. These are connected by rotating a milled head, and the same motion changes the scale on a barrel shaped solid at the same time.

The res: of the instrument is 47ω @ 15°C, 9.12ω, and 0.95ω.

✓ Analysis of a Weston Ammeter # #567 7th Nov: 92.

This instrument reads from 0 to 0.5 amp. and also from 0 to 10 amp.
Its resistance when connected with the lower scale is 0.090ω drop 0.045 volt
" " " " " upper " " 0.004ω " 0.040 "
Its weight all complete without leather case is 5 lbs. 2 oz.
There are 24 turns of wire on the spool, in 2 layers.
The springs have the appearance of dull silver.
There are 7 spires, the external radius being 1.2 cms, Mean rad: abt 0.7
Estimated length 30·8

Breadth by cathetometer: 0.0693, 0.0665, 0.0655, 0.0660; 273 = 0.0668

Thickness: 0.01475, 0.01363, 0.01400, 0.01300; 05538 = 0.01385

Cross section 0.00925 sq: cms A/L = 0.0003004 for one spring = 0.00060 for both
Chord of scale - 1.329 = 83°.17'
Moment of the springs at half load = 0.1355 gm × 3.36 = 0.4552 cm-gms.
" " " " per degree of indication = 0.01094 cm: gms.
" " " " at full load = 0.91 cm: gm:
Resistance of the coil and springs together = 0.507ω @18°C.
" in circuit with the coil = 0.321ω
Total resistance of coil circuit = 0.828ω

✓ Particulars of new model ammeter for 10 ampères 7th Nov. 92.

Mass of disk 13·75 gms. with pointer + counterpoise.
Period of vibration with a certain g. s. wire = 6·255 secs.
" " " loaded with 343 cm² gms. = 18·4 "
Radius of gyration = 1·81
Springs of dime silver = 6¼ spires. Length 9¾" Breadth 0.0575 (0.02264") Thickness 0.0135 (0.0053")
Cross section = 0·007764.
Winding of disk. = 25 double turns of ~~#29 BWG 0.013" dia. 0.016"~~ # 28 B.S. = 0.0126" dia. 0.015" 50 turns in all.
Resistance of wire = 0·389ω @18°C.
" " wire + springs = 0·627ω

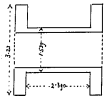
Moment of springs at chord⁻¹ 1·135 = 69°·10' =
1·62 cm × 0·395 gms = 0·640 cm-gms.
2·92 × 0·205 = 0·599 "
2·13 × 0·30 = 0·639 "
1·30 × 0·485 = 0·630 "
2·508
Mean ·627 "

= ·009064 cm-gms: per ° of deviation.
Winding applied = 6 lengths of 7 feet each # 20 BWG. in parallel.
= 0.008425 × 7/6 = 0.00983 ω.
Res: of instrument = 0·01ω approx: actually 0.017

Final test.

by Potentr	1.22	1·93	2·96	4·0	4·75	6·03	7·12	8·07	9·04	9·48	10.28
Indicated	1·17	1·98	3·01	4·0	4·75	5·96	7·04	8·10	9·00	9·45	10·08
Discrepancy	0·05	0·05	0·05	0	0	0·07	0·08	·03	0·04	0·03	0·20

Axial section Full size



Total no. of turns = 611

Layers = 16

Wire = # 25 B.W.G. 0·020" d.c.c. & 0·0225"

Turns per layer = 38

Spool — Internal diameter = 1·539 (0·606")

Diameter over wire = 3·230 (1·272")

Mean diameter = 2·3845

Mean area = 4·46666 sq. cms.

Total area = 2798·20 sq. cms.

Interflange = 2·390 (0·941")

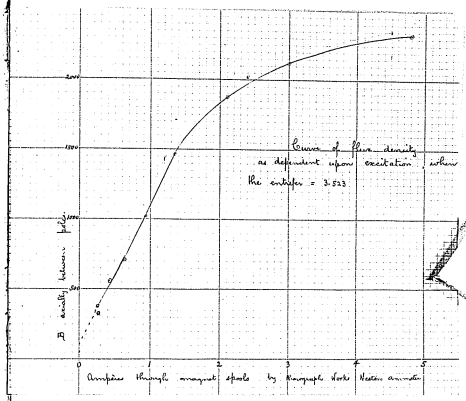
Breadth over all = (1·23")

Mass of spool = 7·26 gms.

Resistance = 4·16 ω @ 20°C

Inductance = 4·91 millihenry.

Layer	Radius r	r^2	No. of turns	nr^2	Σnr^2	$\pi\Sigma nr^2$		
1	0·7959	0·63346	38		887·31	2·4496515		
2	0·8487	0·72021	39		·720	0·2497149		
3	0·8916	0·79495	38		·892	3·4468014		
4	0·9344	0·87289	39		1·103	27977		
5	0·9773	0·95461	38		1·728			
6	1·0202	1·10250	39		891·753			
7	1·1030	1·21660	37		1·217			
8	1·1559	1·33630	38		890·536			
9	1·2087	1·46160	38					
10	1·2616	1·59200	38					
11	1·3144	1·72800	39					
12	1·3674	1·87000	38					
13	1·4203	2·01700	38					
14	1·4731	2·17000	38					
15	1·5260	2·32860	38					
16	1·5788	2·49250	38					
		23·35030						

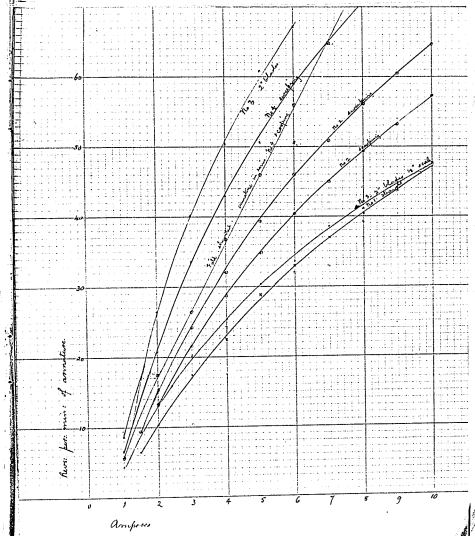


Particulars of new Field Exploring Coil Nov. 11th 92.

The strength of the field existing between the square pole pieces of the large electromagnet at the center was measured with ballistic Galvanometer and a new exploring coil which was unwound and rewound for the purpose. The current in the spools of the large magnet was varied and its influence on the intensity of the field determined. The magnet has 2728 turns, and the outfier was 3.523 (1.398 mm) (1.398 mm)

Source of EMF	EMF at temp.	Capacity	Mean throw	q per div.
1 Ch. cell @ 20.5°C.	1.428×10^{8}	10^{-5} (1 μ)	157.3 :5 throws 1.42810×10^{-7}	9.078×10^{-10} 0.9075×10^{-7}

Test of Gal.	Current thru' magnet Amp. by Potentio	M.M.F.	Throw	Mean throw	Reason est.	q.	φ	B	
1	0.286	981	222 223 221 218 215	220	5250	1.997×10^{-7}	1.048×10^{6}	3735	
2	0.431	1478	170 166 167	167.7	5000 + 5250 ‖ 10,250	1.522×10^{-7}	1.560×10^{6}	5576	
3	0.62	2126	213 212 213	212.7	5000 + 5250 ‖ 10,250	1.931×10^{-7}	1.979×10^{6}	7074	
4	0.915	3138	205 2 207 208	206.7	10000 + 5250 ‖ 15,250	1.876×10^{-7}	2.861×10^{6}	1023.	
5	1.350	4629	118 151 149	149.3	25,000 + 5250 ‖ 30,250	1.355×10^{-7}	4.099×10^{6}	1465	
6	2.10	7200	191 191 191	191	? 25,000 + 5250 ‖ 30,250	1.734×10^{-7}	5.245×10^{6}	1875	
7	3.01	10,320	224 214 212 214	216	25,000 + 5250 ‖ 30,250	1.961×10^{-7}	5.932×10^{6}	2120	
8	3.84 4.50 4.76	16,460	236 236 237	236.3	25,000 + 5250 30,250	2.145×10^{-7}	6.489×10^{6}	2319	
9	4.70		35 34 32	33.7	Small Induction 5250	3.060×10^{-8}	1.606×10^{6}	2033?	

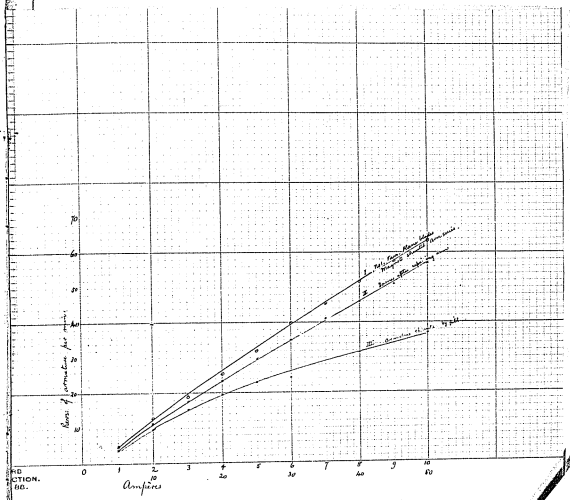

Amperes
0
1
2
3
4
5
6
7
8
9
10
10
20
30
40
50
60

Tests of Motor-Meter No. 5, contd, after rewinding armature.

The field magnets were connected in parallel, and the armatures then in parallel with the fields.

No. of Obs.	Time	C.	Revs.	R.p.m.	R.p.m. per amp.
Fields in parallel, armatures also in parallel (No. 3, with heavy shunt shades on)					
1	1'	1·5	9·4	9·4	6·27
2	-	2·0	15·2	15·2	7·6
3	-	3·0	24·15	24·15	8·05
4	-	4·0	32·0	32·0	8·00
5	-	5·0	39·3	39·3	7·86
6	-	6·0	46·0	46·0	7·67
7	-	7·0	50·85	50·85	7·27
8	-	8·0	56·1	56·1	7·01
9	-	9·0	60·5	60·5	6·72
10	-	10·0	64·75	64·75	6·475
Fields in parallel, armatures also in parallel (No. 4, without shunt shades on)					
1	-	1·25	absent		
2	-	2·0	13·15	13·15	6·58
3	-	3·0	21·5	21·5	7·17
4	-	4·0	28·7	28·7	7·18
5	-	5·0	34·9	34·9	6·98
6	-	6·0	40·35	40·35	6·73
7	-	7·0	45·0	45·0	6·43
8	-	8·0	49·3	49·3	6·16
9	-	9·0	53·1	53·1	5·90
10	-	10·0	57·15	57·15	5·72
Fields in parallel, armatures also in series (No. 4, without shunt shades)					
1	-	1·25	absent		
2	-	1·50	6·4	6·4	4·27
3	-	2·0	10·4	10·4	5·2
4	-	3·0	17·45	17·45	5·82
5	-	4·0	22·8	22·8	5·70
6	-	5·0	28·95	28·95	5·79
7	-	6·0	33·0	33·0	5·50
8	-	7·0	36·9	36·9	5·27
9	-	8·0	40·4	40·4	5·05
10	-	9·0	43·7	43·7	4·85
11	-	10·0	47·6	47·6	4·76

No. of Obs.	Time	C	Revs	R.p.m.	R.p.m. per amp.
Fields in parallel, armatures also in parallel (No. 3, with heavy shunt shades on)					
1	1'	8·0	8·6	8·6	8·6
2	1'	2·0	26·45	26·45	13·2
3	1'	3·0	40·15	40·15	13·38
4	1'	4·0	50·45	50·45	12·61
5	1'	5·0	60·9	60·9	12·18
6	1'	6·0	67·25	67·25	11·21
7	1'	7·0	74·5	74·5	10·64
8	1'	8·0	82·15	82·15	10·27
9	1'	9·07	88·1	88·1	9·82
10	1'	10·0	95·2	95·2	9·52
Fields in parallel, armatures also in parallel (No. 4, heavy shunt shades on)					
1	1'	1·0	6·65	6·65	6·65
2	"	2·0	20·75	20·75	10·375
3	"	3·0	33·6	33·6	11·2
4	"	4·0	42·95	42·95	10·72
5	"	5·0	50·55	50·55	10·11
6	"	6·0	57·0	57·0	9·83
7	"	7·0	64·75	64·75	9·25
8	"	8·0	70·5	70·5	8·81
9	"	9·0	76·5	76·9	8·61
10	"	10·0	83·0	83·0	8·30
Fields in parallel but shunted by heavy armatures in series (No. 4 heavy shunt shades on)					
1	1'	1·0	5·75	5·75	5·75
2	"	2·0	17·35	17·35	8·68
3	"	3·0	26·4	26·4	8·8
4	"	4·0	36·8	36·8	9·2
5	"	5·0	45·9	45·9	9·18
6	"	6·0	56·0	56·0	9·33
7	"	7·0	64·8	64·8	9·25
8	"	8·0	72·8	72·8	9·10
9	"	9·0	82·9	82·9	9·21
10	"	10·0	92·25	92·25	9·23



RD
CTION.
ND.

Tests of Motor Meter #5 cont'd: Nov. 14th

No. of Obs.	C amp	Time	Rev.	Rpm	Rpm/amp	
Fields in parallel & armature shunted by 40 ohms (Shunt #1) Curve #I						
1	0.9	1'	4.5	4.5	5.33	
2	2.0	"	12.9	12.9	6.45	
3	3.0	"	18.9	18.9	6.3	
4	4.0	"	25.45	25.45	6.36	
5	5.0	"	32.2	32.2	6.44	
6	6.0	"	39.8	39.8	6.63	
7	7.0	"	45.6	45.6	6.51	
8	8.0	"	51.6	51.6	6.45	
9	9.0	"	57.45	57.45	6.38	
10	10.0	"	64.5	64.5	6.45	
Fields in parallel & armature shunt. by same (Shunt #1) Curve #II						
1	0.97	1'	3.95	3.95	4.0	
2	2.0	"	11.45	11.75	5.73	
3	3.0	"	17.5	17.5	5.83	
4	4.0	"	23.45	23.45	5.86	
5	5.0	"	29.7	29.7	5.94	
6	6.0	"	35.1	35.1	5.85	
7	7.0	"	41.0	41.0	5.86	
8	8.0	"	46.0	46.0	5.75	
9	9.0	"	51.1	51.1	5.65	
10	10.0	"	56.9	56.9	5.69	
Fields in parallel, armature shunt. by same, & series shunted by same (Shunt No III) Curve No III						
1	7.8	1'	~~30.1~~	~~30.1~~		
2	10.0	"	9.75	9.75	0.975	
3	15.0	"	15.15	15.15	1.01	
4	20.0	"	19.6	19.6	0.98	
5	25.0	"	23.15	23.15	0.926	
6	30.0	"	24.25	24.25	0.808	
7	40.0	"	31.7	31.7	0.793	
8	50.0	"	37.0	37.0	0.740	
9						
10						

12 ~ in 318 sec = 26.50 sec
10 ~ . 265 = 26.5 .
22 ~ . 583 = 26.5 .

39.4 / 32.35 = 1.2178

log 39.4 = 1.5951962
32.35 = 1.5102894
log 0.047 1068 = 2. 6730336
2.3025850 = 0. 3622157
7. 0321945
265.3 = 2. 4237375
2. 6115621 = 0.0004108848

39.4 / 1.3155 = 29.94 = 30
1.3155 = 0.1193744
7. 0332570
0. 3622157
7. 4.3710413
870 = 2. 9397344
2. 6.7.97.38 0.0004976

35.32 / 30.0 = 1.1773
log 0.0172670 = 2. 5021885
2.3025850 = 0. 3622157
7. 2.1810042
30 log = 2. 4831875
2. 3.1312377 0.00013856

12 ~ in 304 sec = 25.3
12 ~ . 305 = 25.4 .
24 ~ . 609 = 25.375

17.125 / 13.25 = 1.2924
log 1.2924 = 0.1117
log 7.67 = 1. 8790501
30 = 1. 4771213
0.29 = 2. 3771238

13.25 = 1.1225
log 1.1225 = 0.0500
log 7.67 = 1. 8790501
30 = 1. 4771213
0.29 = 2. 3771238

log 0.0172173 = 7. 2442360
0.3622157
7. 2.1810250
870 = 2. 9397343
2. 6.3112613 0.00017615

log 76.3 = 1. 8823208
52.5 = 1. 7201093
log 0.0623662 = 2. 2.7094244
2.3025850 = 0. 3622157
2. 5.7228051
2. 4.8287736
2. 8.0893415 = 0.0012348

log 1.31225 = 0.1117943
0.3622157
0.4931550
292 = 2. 4.6.8.3594
2. 3.9.6.0737 0.00031216

12 ~ in 30.1 sec = 25.1005
12 ~ . 30.0 = 25.00
24 ~ . 60.1 = 25.0416

log 60.0 = 1. 7781513
37.9 = 1. 5796393
0.2137 = 0. 3622157
2. 4.6.1.6.6.0
289.5 = 2. 4.6.1.6.6.0
2. 4.6.1.6.6.0
2. 3.8.1.6.6.0
2.4.0.3.2.5.0.6 = 7. 6.0.5.9.6.1
0. 3622157
7. 4.6.7.7.6.5.8
50.4 = 2. 7.0.4.8.3.8
3. 1.9.7.2.8.0.0 0.001575

log 37.9 = 1. 5796393
2.4 = 1. 3802112
0.1894731 = 7. 2.7.7.5.0.7.4
0. 3622157
7. 6.2.4.7.6.3.1
300 = 2. 4.7.7.1.2.1.3
3. 7.6.2.6.1.8 0.0016743

12 ~ in 298 sec = 24.83
12 ~ . 298 = 24.8
24 ~ . 594 = 24.75

log 39.4 = 1. 5951831
23.65 = 1. 3737311
log 0. 5260520 = 7. 3.7.1.0.7.3
0. 3622157
7. 7.1.6.2.4.0
285.5 = 2. 4.5.5.0.6.1
3. 2.6.8.1.7.4 0.0018231

log 24.3 = 1. 3.9.9.5.3.1
= 1. 1.7.2.3.1.0
0.9.2.7.3.1 = 7. 6.3.1.0.7.3
0. 3622157
9.9.3.2.3.4
log 5.82 = 2. 7.6.4.9.3.3.0
2. 2.8.2.9.9.9 0.0016916

39.4 / 30.35 = 1.2978
log 1.2978 = 0.1132
265.3 = 2. 4.2.3.7.5
2. 4.2.3.7.5 = 35.35
39.4
265.3 = log 39.4 / 35.35

(63)

Vibration of Quartz sphere in magnetic field contd. from p. 148. Nov. 18th

Unwound		Field H = 3.00?			C = 1.1 amp K = 12.00				C = 1.76 amp H = 17.50				C = 1.63 amp H = 23.00			
Sum Plus		Time	Sec	Amp	n	Time	Sec	Amp	τ	Time	Sec	Amp	τ	Time	Sec	Amp
		θ = 0.5°				θ = 0.5°				θ = 0.5°				θ = 0.5°		
0	1	15.01.11	30.2		0	17.01.15	56.2		0	16.53.37	79.8		0	16.00.27	66.3	
	2	. 20	69.6	39.4		05.09	10.1									
	3	.37	30.4	39.2	1	.15	85.3	75.2	1	18.02	78.3	61.1	1	.22	67.3	39.0
	4	.50	69.5	39.1		.24	11.5	73.1		.15	18.7	59.6		.34	29.3	38.0
2	5	9.03	30.55	38.95	2	.47	83.8	72.3	2	.28	76.8	58.1	2	.46	66.4	37.1
	6	.41	69.5	38.75		9.00	12.6	71.2		.40	19.9	56.9		.59	30.1	36.3
3	7	.30	30.5	38.5												
	8	.43	69.1	38.3	3	.12	82.7	70.1	3	.53	75.5	55.6	3	103.11	65.5	35.4
4	8	.57	30.95	38.05		.25	13.9	68.8		55.05	20.25	54.35		.24	30.95	34.65
	9	10.10	68.9	37.95	4	.37	80.9	67.0	4	.18	74.3	52.05	4	.45	64.7	33.75
5	10	.23	31.1	37.8		.51	14.95	65.95		.30	22.3	52.0		.69	31.8	32.9
	11	.36.5	68.6	37.5	5	10.03	80.3	65.35	5	.43.5	73.25	50.95	5	104.01	63.9	32.1
6	12	.50	31.15	37.2		.16	16.3	64.0		.56	23.4	49.85		.14	32.5	31.4
	13	11.03	68.15	37.0	6	.28	79.2	62.9	6	56.08	72.0	48.6	6	.26	63.2	30.7
7	14	.17	31.5	36.9		.41	17.6	61.8		.21	24.44	47.5		.39	33.2	30.0
	15	.29	68.15	36.65	7	.53	78.2	60.8	7	.33	71.0	46.6	7	.51	62.5	29.3
8	16	43	31.8	36.35		11.07	18.3	59.9		.46	25.4	45.6		105.03	34.5	28.7
	17	.57	67.95	36.15	8	.19	77.3	59.0	8	.58.5	69.9	44.5	8	.16	61.9	28.1
9	18	12.10	31.9	36.05		.32	19.1	57.9		59.11	26.14	43.5		.28	36.3	27.6
	19	.23	67.8	35.9	9	.44	76.3	56.9	9	.23.5	68.1	42.7	9	.40	60.3	27.0
10	20	.36	32.2	35.6		.58	19.9	56.1		36	27.2	41.9		.53	59.95	26.35
	21	.49.5	67.35	35.35	10	12.10	75.1	55.5	10	.48	68.3	41.1	10	106.05	60.8	25.85
11	22	13.05	31.6	35.05		.23	20.8	54.6		58.01	28.0	40.3		.18	35.5	25.3
	23	.16	66	34.45	11	.35	74.8	54.0	11	.13.5	67.14	39.4	11	.30	60.2	24.7
12	24	.29	31.4	34.6		.46	21.7	53.0		.24	28.7	38.7		.42	36.0	24.2
	25	.42	67.65	34.25	12	13.00	73.9	52.1	12	.34	29.4	37.8	12	.55	59.65	23.65
13	26	.56	33.3	34.35		.13	22.4	52.5		.51	29.4	37.3		107.07	36.5	23.15
	27	14.09	67.5	34.2	13	.26	72.9	51.5	13	59.03	66.0	36.6	13	.20	59.2	22.7
14	28	.22.5	33.4	34.1		.39	23.3	50.4		.16	29.9	36.1		.32	36.9	22.3
	29	.38	67.35	33.85	14	.51	72.8	48.8	14	.28	64.9	35.0	14	108.44	58.8	21.9
15	30	.49	33.7	33.55		14.05	24.2	47.9		.41	30.8	34.1		.58	37.3	21.5
	31	15.2	67.0	33.3	15	16.5	71.0	46.8	15	.54	64.4	33.6	15	109.09	58.3	21.0
16	32	.16	33.9	33.1		.29	24.2	46.5		17.06	31.6	32.8		22	37.6	20.7
	33	.29	66.8	32.9	16	.42	70.6	45.4	16	01.19	63.8	32.2	16	.33	58.0	20.14
17	34	.42	34.1	32.7		.55	24.9	45.7		.31	32.2	31.6		.45	38.0	20.0
	35	.55	66.7	32.6	17	17.07	70.15	45.6	17	02.5	63.3	31.1	17	.58	57.6	19.6
18	36	16.08	34.3	32.4		.20	25.6	44.9		.56	32.6	30.7		110.10	38.3	19.3
	37	.22	66.4	32.1	18	.33	69.75	44.15	18	03.08	62.45	29.85	18	.23	57.3	19.0
19	38	.35	34.7	31.7		.45	26.8	44.95		.21	33.1	29.35		.35	38.7	19.6
	39	.49	66.0	31.3	19	.58	70.6	45.8	19	.33	62.4	29.3	19	.47	57.0	18.3
20	40	17.02	34.95	31.05		18.10.5	25.6	45.0		.45	33.6	28.8		50.00	38.95	18.05
	41	.15	65.6	30.85	20	.23	69.95	44.35	20	.58	61.8	28.2	20	.13	56.6	17.65
21	42	.28	35.2	30.4		.36	26.2	43.75		62.11	34.1	27.7		.25	39.25	17.35
	43	.41	65.4	30.2	21	.49	69.40	43.2	21	.23	61.3	27.2	21	.37	56.14	17.15
22	44	.54	35.44	30.0		19.01	26.8	42.6		.36	34.3	27.0		111.48	39.55	16.85
	45				22	.14	68.7	41.9	22	.48	60.9	26.6	22	07.02	56.1	16.55
	46					.26	27.2	41.5		63.01	34.9	26.0		.14	39.8	16.3
	47				23	.39	68.3	41.1	23	.13	60.4	25.5	23	.27	55.42	15.62
	48					.52	27.8	40.5		.26	35.4	25.0		112.39	40.35	15.07
	49				24	18.05	67.8	40.0	24	.38	59.95	24.45	24	.51	55.22	14.67
	50											24.25				

Test of Pico Box Model Edison Fan Motor 16th Nov.

Connected model by belt to an Edison 6-polar-turn motor, and separately excited the field, measuring the terminal P.D.

No. of Obs.	Amp. in Coil	MMF	Rpm	Rpsec.	E.M.F.	E.M.F. per turn	Φ				
1	0.5		3051	50.9	0.832	0.01635	10,900				
2	1.0		3051	50.9	1.060	0.02082	13,880				
3	1.43		3131	52.2	1.285	0.02461	16,410				
4	1.88		3186	53.1	1.443	0.02717	18,110				
5	2.35		2970	49.5	1.533	0.03097	20,650				
6	2.75		2835	47.25	1.631	0.03452	23,020				
7	3.10		2781	46.35	1.695	0.03657	24,380				
8	3.62		2646	44.1	1.877	0.04257	28,380				
9	4.15		2646	44.1	1.933	0.04383	29,220				
10											

$\frac{48.0}{29.3}$ = 1.681292 − 1.466836 = 0.214456 = log 1.638

= T. 3311711 − 2. 7863168 = 2.524543 − 0.362257 = 2.162286 = 0.0008322

$\frac{62.5}{14.6}$ = 1.796876 − 1.163829 = 0.632047 = 312

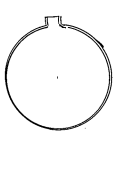
T. 7979233 − 2. 4941866 = 3.304377 − 0.362257 = 3.042120 = 0.00104483

$\frac{37.25}{13.5}$ = 1.571126 − 1.398741 = 0.172385 = log 1.487

T. 6367261 − 3633257 = 2.733004 − 0.362257 = 2.370746 = 0.0233101

$\frac{46.25}{31.8}$ = 1.664987 − 1.502629 = 0.162358 = log 1.455

T. 2163343 − 3633257 = 1.529086 − 0.362257 = 1.166829 = 0.0011273



On the oscillatory damping of non-conducting spheres in a magnetic field. contd. from p. 150

The next sphere tried was composed of plaster of Paris, weighing 26.992 gms. Its minimum diameter was 3.546, and its maximum 3.852, making a mean radius of $\frac{3.699}{2}$ = 1.777. This was attached by sealing wax to a glass stem 19.5 long and 0.38 in diameter. A mirror was attached by beeswax to the upper part of the stem, and a suspension wire of Pt-Ir 0.0079 diam. and 35.0 long. Dist. from scale to mirror 148

In unexcited field, this sphere executed 45 vs in 619 secs. = 13.752 secs.
The amplitudes at 17.22.36 were 22.7 71.0 23.1 = 48.3 (26.05 + 22.25)

The corrected amplitude = 48.0
The observed amplitude at 17.32.47.5 = 29.3 practically correct.
Equation of series $\theta = \Theta\, \varepsilon^{-0.000807t} \sin\left(\frac{2\pi t}{13.752}\right)$

With a current in the magnet coils of 2.186 amp. corresponding to B = 1900, the sphere completed 27 periods in 314 secs. = 11.63 secs. per vs
The amplitudes at 9.30.9.5 were 62.2 (corrected)
" " " 9.35.21.5 " 14.6
Equation of series $\theta = \Theta\, \varepsilon^{-0.006658t} \sin\left(\frac{2\pi t}{11.63}\right)$

With a current in the magnet coils of 4.26 amp. corresponding to B = 2200 the sphere completed 28 periods in 193 secs. = 6.892 secs. per vs
The amplitudes at 11.14.17 were 37.25 (corrected)
" " 11.17.24 " 13.50
Equation of series $\theta = \Theta\, \varepsilon^{-0.005310t} \sin\left(\frac{2\pi t}{6.892}\right)$

Again with unexcited field as check
The sphere completed 25 periods in 318.5 secs = 12.72 secs per vs
The amplitudes at 12.22.22.5 were 46.25 (corrected)
" 28.05.5 " 31.8
Equation of series $\theta = \Theta\, \varepsilon^{-0.0011298t} \sin\left(\frac{2\pi t}{12.72}\right)$

The next sphere was a glass bulb whose dimensions are as follows:-
Dia. Equatorial diameter. Max: 3.752 Min 3.704 Mean 3.728 } 3.72 = 1.86
" Polar " " 3.729 3.693 " 3.711
From lower pole to top of neck 4.27
Mass. 3.722 gms. Contents 25.889 c.c. From which int r = 1.855
Calculated mean thickness = 0.025
This globe was secured by a cork to a glass stem 19.8 long and 0.15 diam.
The whole system was suspended by a fine copper wire long & in diam.
In an unexcited field, the amplitude of the globe made one period in 18.125 secs. 8 vs in the secs. The amplitude diminished from 29.2 to 8.6 in 96 secs.
Equation of series $\theta = \Theta\, \varepsilon^{-} \sin\left(\frac{2\pi t}{18.125}\right)$

In the fully excited field, the globe executed 8 vs in 1.22 secs = 15.25 secs per vs and the amplitude diminished from 79.60 to 25.60 in 111 secs
Equation of series $\theta = \Theta\, \varepsilon^{-} \sin\left(\frac{2\pi t}{15.25}\right)$

The globe was now lightly filled with dried flowers of sulphur (S) and tested with the same suspension. In unexcited and neutral field, the globe made 12 vs in 506 secs = 42.2 secs. per vs. Also the amplitude diminished from 72.2 (corrected) to 20.6 in 465 secs
Equation of series $\theta = \Theta\, \varepsilon^{-} \sin\left(\frac{2\pi t}{42.2}\right)$

In the fully excited field (B = 2200) there were evident signs of magnetic influence, much torsion being necessary to restore zero. Globe made 16 vs in 141 secs. = 8.819 secs. The amplitude diminished from 21.3 to 5.0 in 136.6 secs.
Equation of series $\theta = \Theta\, \varepsilon^{-} \sin\left(\frac{2\pi t}{8.819}\right)$

Tests made on McKenna-Weed Meter Nov. 22nd 92.

At Lynn T.H. Works. Meter Dept. Four McKenna meters were under trial. Much difficulty had been experienced in obtaining a regular and agglomerate deposit of mercury in the tube, and Mr McKenna employed a glass rod with which the column was stirred in order to make it coalesce. This resulted in a reduction of about 0.4" in the column length in one case.

One meter was taken to the testing room, and first connected up so that the shunt was out of circuit, and the meter bottle was in direct circuit with a milliammeter. A D'Arsonval galvanometer with a high res. added was connected round the cell at the same time to observe the pressure.

Millivolts thro. cell	Deflection on D'Arsonval	Res. in cct. incl. D'Arsonval	Value of 1 div. in volts	Volts on cell	Resistance of cell	Drop.	η		
0.00922 1	75	3008 ω	0.000112	N.001065	1.56 ω 1.59 ω	0.00156	0.00909		
0.01964 2	82			0.001165		0.00312	0.00852		
0.02946 3	90			0.001278		0.00468	0.00810		
0.03928 4	99			N.001406		0.00624	0.00782		
0.04910 5	109			N.001548		0.00780	0.00768		
0.05892 6	120			0.001704		0.00936	0.00768		
0.06874 7	131			0.001860		0.01092	0.00772		
0.07856 8	142			0.002017		0.01248	0.00769		
0.08838 9	153			N.002173		0.01404	0.00769		
0.09820 10	164			N.002329		0.0156	0.00769		

0.0066 volt on D'Arsonval cct. gives 1.6.5 divs. ∴ 1 div = 0.000112 — 0.02329
0.012 - - - - - 84 — 0.000143 — 0.01716
0.018 - - - - - 127 — 0.000142 — 0.02555
0.024 - - - - - 172 — 0.000139.5 — 0.0156

Took another series reaching higher. The results do not seem reliable

Time in cell Missing	Gross Wgt.	Cutting Tare	Res. in cct	Value of 1 div	Volts on cell	Deflection of D'Arsonval	Res.	Drop	η	
0.001	2.838	3.908 ~~3.967~~	Room?	0.000433	0.0156	36	1.56 ω	0.0561 0.007	0.0755 0.0086	
0. 2	7.916	7.016 ~~7.934~~			0.01969	45		0.0122 0.0114	0.00827 0.0058	
3	12.914	11.734 ~~12.901~~			0.02469	56.5		0.0183 0.021	0.00617 0.00347	
4	17.952	15.623 ~~17.944~~			0.02968	69		0.0204 0.025	0.00768 0.00188	
5	4.19	19.56 ~~20.365~~			0.03795	83		0.0305 0.035	0.00590 0.00015	
6	27.981	23.250 ~~26.802~~			0.04244	98		0.0366 0.043	0.00576 0.00041	
7	32.866	27.336 ~~31.664~~			0.04980	115		0.0427 0.049	0.00740 0.00080	
8	36.704	31.246 ~~35.746~~			0.05760	133		0.0488 0.055	0.0088 0.00160	
9	40.522	35.173 ~~39.503~~			0.06582	152		0.0579 0.063	0.00792 0.00212	
10	44.338	39.08 ~~43.09~~			0.07336	174		0.0610 0.070	0.01236 0.00336	

7236
4920
2316

23.45 / 6. = 3.908 × 0.982 = 3.838

Tests of McKenna Meter contd.

The meter was connected as in the practical mode of operation, with a milliamperes of 17.165 v. (shunted by 6-) in the cells circuit. An ammeter was connected in the main cct.

Reading No.	Amp	Volts	Wtp γ	Wtp 2.422	Indx 2.487		Amp.		γ	Volts			Amp		Wtp γ			
							1.0 4.0 8.0		$\times 10^{-3}$ 8.16 7.25						$\times 10^{-3}$			
1	0.5	0.05	0.00015	0.00231	0.00570								0.5		0.32			
2	1.0	0.10	0.00099	0.02216	0.1169		7.5		6.82				1.0		0.81			
3	1.5	0.15	0.00162	0.03753	0.1677		7.0		6.35				1.5		1.31			
4	2.0	0.2	0.00191	0.05287	0.2254		6.5		5.91				2.0		1.80			
5	2.5	0.25	0.00237	0.06823	0.2799		6.0		5.41				2.5		2.24			
6	3.0	0.3	0.00280	0.07410	0.3305		5.5		4.99				3.0		2.63			
7	3.5	0.35	0.00304	0.08994	0.3874		5.0		4.53				3.5		3.17			
8	4.0	0.4	0.00370	0.09775	0.4367		4.5		4.08				4.0		3.60			
9	4.5	0.45	0.00420	0.1110	0.4957		4.0		3.56				4.5		4.07			
10	5.0	0.50	0.00466	0.1231	0.5495		3.5		3.08				5.0		4.25			
11	5.5	0.55	0.00515	0.1361	0.6079		3.0		2.62				5.5					
12	6.0	0.60	0.00554	0.1464	0.6535		2.5		2.19				6.0					
13	6.5	0.65	0.00600	0.1586	0.7084		2.0		1.71				6.5					
14	7.0	0.7	0.00646	0.1707	0.7622		1.5		1.26				7.0					
15	7.5	0.75	0.00697	0.1824	0.8156		1.0		0.80				7.5					
16	8.0	0.8	0.00737	0.1948	0.870		0.5		0.32				8.0					
	7.0 1.00		1.00 551															

log 77.8 1.891796
32.25 1.508547
38.247 7.5825747
3.6232157
1.9494904
225 2.3521825
3.5926099 0.0039129

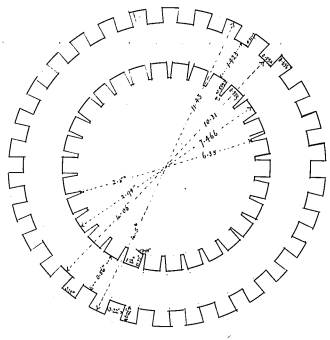
20. 1.30103
8.85 0.9469433
0.3540567 7.5491016
0.3622157
1.9113171
127.5 2.1055102
3.4056069 0.1276394

Experiments on the oscillatory damping of Non Conducting Spheres cont.: from p. 155

The next spheroid experimented upon was of paraffin wax, prepared by melting this wax into a glass globe, and breaking off the glass shell when cool. The mass of this spheroid = 26.0 gms. The equatorial diam. was 3.792 max 3.736 min = 3.764 mean. Polar diam. 3.987. The same suspension was employed as in the last case.

In an unexcited field this spheroid made 6 ∿ in 226 secs = 37.6 Amplitude 77.8 mm. to 32.25 mm. in 225 secs. $\theta = \theta_0 e^{-0.0039129t} \sin\left(\frac{2\pi t}{37.6}\right)$

In the fully excited field the spheroid made 6 ∿ in 165 = 36.25 Amplitude 20.0 to 8.85 in 127.5 secs. $\theta = \theta_0 e^{-0.00639t} \sin\left(\frac{2\pi t}{36.25}\right)$



Electromagnetic Design for a Phonograph Motor.

Type — Bipolar ~~[illegible]~~, gramme ring armature with teeth.

Speed — 600 r.p.m. = 10 r.p.s.

Battery — 3 Edison Lalande cells. Total EMF 2 volts

Drop in Battery = (0.05 × 3) × 3 = 0.45 volt

" " leads = 0.10 × 3 = 0.3

P.D. at M.T. = 1.25 volts.

E.M.F. of motor = 1.2 "

Useful flux = 90,000 c.g.s.

Armature dimensions Bot. diam = 4.5" (11.43)

Tops " = 2.5" (6.35)

Breadth of teeth = 0.25" 0.638

Depth of grooves = 0.22" × 0.22" 0.559 × 0.559

Depth of armature = 1.1" 2.75

Cross section of do. = 3.97 sq. ins. allowing 90% = 3.77 sq. ins. available.

B in armature = 14,950

" " teeth = 6,250.

Number of wires = 120 in all, 40 in each groove.

Winding = # in 30 S.W.G. D. 0.283" d.c.c. b 0.297"

Length of each turn = 4.5" 0.375

Total length of wire = 40'

" " resistance = 0.066 Ω

" " of armature = 0.0165 Ω

Drop in motor = 0.05 volt.

Gap length = 0.03125" (1/32") 0.08

Polar surface = 22 sq. ins. effective.

Reluctance in air = 0.08/11 = 0.00728

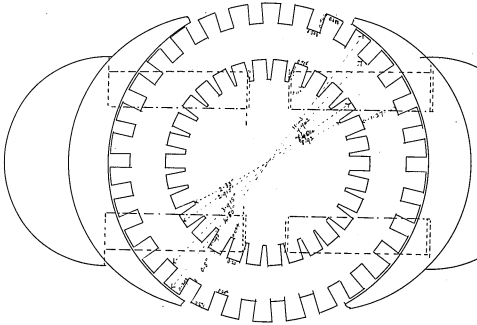
Total calculated ampere-turns = 0.509

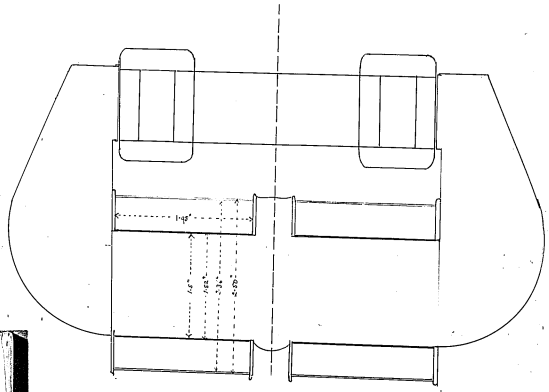
M.M.F. for 90,000 = 810 = 648 ampere turns.

Total flux in magnet = 1.5 × 90,000 = 135,000.

Cross section of core = 16,875 sq. ins. @ B = 8,000

Diameter = 4.625 ins. = 1.825".





Electromagnetic Design of Phonograph Motor

Type = Shunt wound bipolar gramme ring with teeth.

Speed = 600 rpm = 10 rps.

Battery = 3 Edison-Lalande cells = 2 volts total EMF.

Drop in battery $(3 \times 0.05) \times 3 = 0.45$ volt

" " leads $= 0.10 \times 3 = 0.20$

P.D. at terminals = 1.25 volts.

Current = 3 amp. estimated.

Power absorbed = 3.75 watts " .

Flux = 66.670 c.c.s. lines. (0.66 millimaxwell)

No. of wires = 180, 6 in each groove.

EMF of motor = 1.2 volts.

Armature dimensions

Ext. diameter = 4.5" (11.43)

Int. " = 2.33" (5.92)

Breadth of body = 1.0" (2.54)

No. of teeth = 30

Breadth of tooth = 0.271" (0.688) 0.013" inbound

Breadth of groove = 0.20" (0.508)

Depth of groove = 0.293" (0.744)

Breadth of core = 0.5" (1.27)

Cross section " " = 3.225 sq. inches 95% = 3.064 sq. inc.

" in core = 10.880. In teeth. 5000. (50 micrograuss)

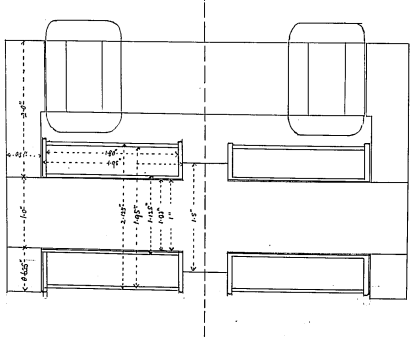
Body insulation = 0.01".

Winding = 3 layers of 2 turns in each groove # 15 BWG = # 13 B&S 0.072"

d.c.c. " 6 0.056".

Same Armature in Wrought Iron Field.

Spools slipped on.



Electromagnetic Design of Phonograph Motor

Type = Shunt wound bipolar gramme ring with teeth.

Speed = 600 r.p.m. = 10 r.p.s.

Battery = 3 Edison Lalande cells = 2 volts total E.M.F.

Drop in battery) (3 × 0.05) × 3 = 0.45 volt

" leads = 0.10 × 3 = 0.20

P.D. at terminals = 1.25 volts.

Current = 3 amp. estimated.

Power absorbed = 3.75 watts " "

Flux = 66,670 c.g.s. lines. (0.66 millivolts)

No. of wires = 180, 6 in each groove.

E.M.F. of motor = 1.2 volts.

Armature dimensions

Ext. diameter = 4.5" (11.43)

Int. " = 2.33" (5.92)

Breadth of body = 1.0" (2.54)

No. of teeth = 30

Breadth of tooth = 0.271" (0.688) 0.003" internal

Breadth of groove = 0.20" (0.508)

Depth of groove = 0.293" (0.744)

Breadth of core = 0.5" (1.27)

Cross section " " = 3.225 sq. inches 95% = 3.064 sq. ins.

B in core = 10,880. In teeth. 5000. (50 kilogauss)

Body insulation = 0.01"

Winding = 3 layers of 2 turns in each groove # 15 B.W.G. = # 13 B.S. 0.072" d.c.c. to 0.086".

Length of mean turn = 26.1" = 3.4'

Total length of wire = 61.2'

" " " " = 0.122 m.

Mean arm. res. = 0.031 ω

" drop in arm. = 0.08 volt.

Weight of armature = 0.961 lb.

Stifer's Bearings = 0.025" 0.038

Arm. Polar surface = 17.2 sq. cms.

Air reluctance = 0.038/17.2 = 0.0023 × 2 = 0.0065

Total estimated rel. = 0.0075 = 7.5 megawebers

MMF. needed = 3700 gilb. = 370 amp. turns. say 400.

Current in field = 0.33 amp.

Turns on " = 900

" " each spool = 450.

Cross section of core = 12.6

B in " = 9,770 (cast iron)

Flux = 100,000

Diam. of " = 4 cms. = 1.5".

Mean turn = 0.5'

Winding of field = 10.0 layers of 46 turns each # 20 B.W.G. 0.035" d.c.c. 0.042" 460 turns in all. on each spool.

Depth " winding = 0.42".

Length " wire = 46.25'

Weight " " = 1.57 lbs.

Resistance " " = 3.58 ω @ 20°C.

Energy " " = 0.4 watts.

Mass of wire in arm = 2.25 lbs. 1014 gm.

" " copper " = 1.0 "

" " iron " field = 6.0 2720 "

" " copper " = 1.6 "

With wrought iron field magnet

Core diam. = 1.0" = 2.54

Cross section = 0.785" 5.07 sq. cms.

With 20% leakage B = 16,000 φ = 80,000

Spool diameter Int. = 1.125"

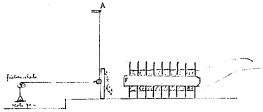
Ext. = 2.125"

Initial length = 1.80"

Winding = 1.25 lbs. of # 21 B.W.G. = # 20 B.S. 0.032" d.c.c. & 0.039" in 10 layers of 44 turns each = 440 turns. on each spool = 880 turns in all.

Total length = 400'

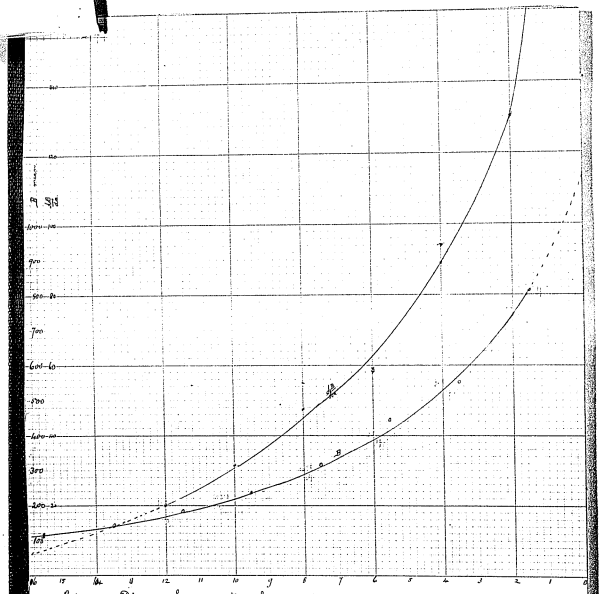
" resistance = 4.0 ω @ 20°C.



$0.637^3 = 0.2585$

$\frac{4\pi}{3} = 4.1888$

$\frac{4\pi r^3}{3} = 1.083$



Measurements of Magnetic Force upon an iron sphere. 3rd Dec. 92

A sphere of iron 1.274 in diam., nearly uniform, weighing 8.5 gms. was supported by a silk thread 35" long from a wooden support. From a small brass hook in the ball, another silk thread ran over delicate friction wheels and supported a scale pan weighing 0.475 gms. A zinc plate stood as a non-magnetic barrier, and when the horizontal thread was slack, the sphere was set to just touch it, hanging vertically from A, the magnet being inverted. A current of 6.1 amp. was then passed through the magnet, and the pulls necessary to just dislodge the sphere noted, with the distance of the sphere from F. The flux was also determined by setting the coil of gauge 150 at varying distances from F, making and breaking the magnet circuit, and determining the effect upon the ballistic galvo.

Pull No.	Current in magnet	Dist. of centre of sphere from F	Wt. used in bucket	Total weight grms.	Pull dynes	B	μB	BB'	ratio $\frac{BB'}{B}$	$BB'r^2$
1	6.1 amp.	2.275	27	27.475	26950	710 685	126 118	88940 85[illegible]	3.247	20,900
2		3.075	22.5	22.975	22,520	615 590	105 100	64,870 [illegible]	2.8614	12,250
3		3.625	19.0	19.475	19,105	560 520	96 90	53,760 [illegible]	2.8114	12,330
4		4.125	12.0	12.475	12,240	470 435	78 75	36,660 [illegible]	2.995	8,780
5		5.675	8.3	8.775	8,608	400 370	65 62	26,000 [illegible]	2.021	5,930
6		6.625	6.20	6.975	6,844	360 310	57 56	20,520 [illegible]	3.134	4,485
7		7.675	4.3	4.775	4,685	310 280	49 41	15,190 [illegible]	3.242	2,650
8		8.325	3.2	3.675	3,605	275 215	42.5 40	11,690 [illegible]	3.243	
9		9.195	2.4	2.875	2,821	245 180	36 38	8,820 [illegible]	3.127	
10		10.175	1.65	2.125	2,084	218 150	32 30	6,976 [illegible]	3.348	
11		11.195	1.05	1.525	1,496	195 120	24 22	4,679 [illegible]	2.987	
12		12.325	0.70	1.175	1,153	190 105	19 20	3,040 [illegible]	2.637	
13		13.325	0.40	0.875	858	140 92	14.5 15	2,030 [illegible]	2.366	
14		14.175	0.20	0.675	662	130 82	12. 13	1,560 [illegible]	2.357	
15		15.575	0.0	0.475	466	115 70	7 9	805 630	1.727	
16		15.125	0.1	0.575	564	120 75	8.5 10	1,020 750	1.508	

EMF	Capacity	q	Mean throw	q from this.
1 D. cell @ 18°C	1 F			
1.4307×10^8	10^{-6}	1.4307×10^{-7}	126.4	1.132×10^{-7}

Dist. of centre from F	R. in air	R. of ext.	Throw	q	Φ	B
1.55	10,000	15,210	132	1.494×10^{-7}	2.272×10^{6}	812
3.55	"	"	95	1.075 "	1.635 "	584.4
5.55	0	5210	210.5	2.383 "	1.242 "	443.9
7.55	0	"	151.5	1.715 "	8.938×10^{5}	319.4
9.55	0	"	112.	1.268 "	6.606 "	236.1
11.55	0	"	86.	0.9736 "	5.073 "	181.3
13.55	0	"	67.	0.7584 "	3.952 "	141.2
15.55	0	"	52.5	0.617	3.215 "	114.9